Design and Unsustainability (Design Exclusion) –

Structuring sustainable design approaches for socially responsible practices

(Design for equal usability and accessibility)

Rihan Hamdy Rihan Hussein

A thesis submitted in fulfillment of the requirements for the degree of
Doctor of Philosophy

Braunschweig University of Art

Germany

January 2022

Date of oral examination: **12 January 2022**

Supervisors:

Prof. Dr. -Ing. Habil. Wolfgang Jonas

Professor of Design Sciences

Braunschweig University of Art – Germany

Prof. Dr. -Ing. Gerhard Glatzel

Professor of Construction and Materials

Braunschweig University of Art – Germany

For Citation:

Hussein, Rihan H. R.: 2022, *Design and Unsustainability (Design Exclusion) – Structuring sustainable design approaches for socially responsible practices (Design for equal usability and accessibility)*, PhD thesis, Braunschweig University of Art, Braunschweig, Germany.

Dedicated to those who have been sharing the journey with me, **my dear family**

‘Diversity is the one true thing we all have in common.’

Author Unknown

‘Diversity in the world is a basic characteristic of human society, and also the key condition for a lively and dynamic world as we see today.’

Hu Jintao

‘Diversity is the magic. It is the first manifestation, the first beginning of the differentiation of a thing and of simple identity. The greater the diversity, the greater the perfection.’

Thomas Berry

‘Differences challenge assumptions.’

Anne Wilson Schaef

‘I can tell you, without diversity, creativity remains stagnant.’

Edward Enninful

Without equity, development is useless.

Rihan H. R. Hussein

‘Our ability to reach unity in diversity will be the beauty and the test of our civilization.’

Mahatma Gandhi

‘Society is unity in diversity.’

George Herbert Mead

The greatest success isn’t to create a need or a designed thing to satisfy a need but to equally fulfill it.

Rihan H. R. Hussein

Declaration

I certify herewith that the content of this thesis is the result of original work, which has been carried out by the author since the official commencement date of the approved research programme, and that the work of this thesis hasn’t been submitted previously, in whole or in part, to qualify for a high degree or any other academic award.

Rihan Hamdy Rihan Hussein

Braunschweig, 12th of January 2022

Acknowledgements

With this thesis, I come to the end of the road of my PhD studies, which I couldn't have accomplished without the ***Hand of God*** and the support of several people, to whom I am highly indebted.

First and foremost I would like to express my sincere gratitude to my supervisor Prof. Dr. -Ing. Habil. ***Wolfgang Jonas*** for allowing me to fulfill my PhD studies in Germany. I thank him for adopting my research point, which had been a real challenge for me, and which without his continuous support, encouragement and valuable feedback wouldn't have been possible to conclude.

Special thanks go to Prof. Dr. -Ing. ***Gerhard Glatzel*** for officiating as a co-supervisor and for his comments and evaluation.

This research wouldn't have been possible without the distinctive auspice of the Braunschweig University of Art – Germany, and the financial and administrative assistance of the Ministry of Higher Education of the Egyptian Government and Helwan University – Egypt. Special sincere thanks go to the whole staff of the Interior Design and Furniture department in the Faculty of Applied Arts – Helwan University, Egypt.

My thanks are also to Mrs. *Susanne Fleischhacker,* Mrs. *Ulrike Kaschner* and Mrs. *Katrin Grabke* from the Braunschweig University of Art.

Finally, I would like to thank my whole family for their patience, endurance and support throughout the journey of my PhD studies. I would never have been able to complete this without the warm prayers of my parents. I'm grateful to them for their continuous love, support and encouragement throughout the years.

Zusammenfassung

Die Welt befindet sich in einem *sozial unhaltbaren* Zustand. Die Bedingungen der *sozialen Ungerechtigkeit* bei der Befriedigung *menschlicher Bedürfnisse* haben die Grenze überschritten. Dieser Zustand hat in ein und derselben Gesellschaft und in verschiedenen Bevölkerungsgruppen stattgefunden, und seine Auswirkungen sind zu klassischen "*wicked problems*" geworden. Solche Zustände „sind das Ergebnis der Annahmen der utilitaristischen Philosophie, die der Mainstream-Ökonomie zugrunde liegt und der das Risiko sehr schlechter Auswirkungen für einige Individuen in der Gegenwart oder für alle in einigen alternativen Zukünften gleichgültig ist“ (Dresner, S.: 2008, S. 4).

Dieser Zustand ist untrennbar mit dem *Design* verbunden. Man könnte einfach sagen, dass es eine Korrelation zwischen dem Zustand des Designs (*Designparadigma*, *Studien* und *Forschung*, die die *Designpraxis* leiten) und dem Zustand der Welt gibt, wenn man die Rolle des Designs bei der *Erfüllung menschlicher Bedürfnisse* anerkennt. Das oberste Ziel von Design ist die Befriedigung menschlicher Bedürfnisse (Margolin, V.: 2002, S. 25). Dementsprechend impliziert der *sozial nicht nachhaltige* Zustand der Welt, dass es einen Fehler in den vergangenen und gegenwärtigen *Designpraktiken* gibt; und dass die gegenwärtigen verschiedenen Formen von Designparadigmen, -studien und -forschung keine gute Arbeit leisten, um die Praktiken in Richtung Nachhaltigkeit zu lenken.

Leider dienen die meisten professionellen Designpraktiken im vorherrschenden System – *Produktion für den Markt* – dem Kommerz und der Kommerzialisierung (Chick, A.: 2011, S. 70), deren Hauptzweck des *Designs für den Markt* darin besteht, gestaltete Dinge für den *Profit (Eigeninteresse)* zu schaffen. In der Tat ist Design eher an andere Ziele und Werte gebunden als an seine eigentlichen; „zunehmend handelt Design als Dienstleistung auf Anweisung, anstatt im ursprünglichen Sinne zu handeln“ (Fry, T.: 2009, S. 25) oder gemäß seiner eigenen Theorie. Es hat seinen freien Willen und seine Fähigkeit zur Kontrolle verloren. Angetrieben von der Erfüllung des kommerziellen Auftrags dient es „einer instrumentellen Herstellungsweise, die Dinge ins Leben ruft, ohne zu wissen, welche Folgen sie haben werden“ (ebd.: S. 26).

In dieser Studie wurde das Phänomen "*der Zusammenhang zwischen Design und dem Zustand der sozialen Nicht-Nachhaltigkeit in der Welt*" untersucht, um Mängel in den vergangenen und gegenwärtigen *Designpraktiken* aufzudecken, die diesem Zustand zugrunde liegen, und dementsprechend geeignete Lösungsansätze vorzuschlagen, um ein erneutes Auftreten dieses Phänomens zu vermeiden.

Die Studie hat bewiesen und anerkannt, dass *ungleiche Designpraktiken* oder die *Nichtberücksichtigung der dynamischen Vielfalt der Charakteristika des menschlichen Kontexts in Designpraktiken* (*Designexklusion*) eine nachgewiesene Hauptursache für dieses Phänomen ist. Dies wurde durch die umfassend Bewertung der Interaktionseffektivität innerhalb der *individuell gestalteten Zugangs- und*

Nutzungsbeziehungen erreicht, durch die *Gleichheit* erreicht werden könnte, oder durch die Bewertung, wie gleichberechtigt die *Zugänglichkeit* und *Nutzbarkeit* von gestalteten Dingen für verschiedene Menschen ist.

Das vorherrschende Design-Paradigma, das von der Erfüllung kommerzieller Vorgaben angetrieben wird, ist im Wesentlichen als Reduktion der Vielfalt formuliert. Es geht vom *Durchschnittsfall* aus (dem Durchschnittsnutzer oder der Standardumgebung) oder zielt auf bestimmte Personen, Gruppen oder Gesellschaften ab. Unflexible Gestaltungsmodelle, denen es an einer Vielfalt von Maßnahmen mangelt, um der *Vielfalt* und *Dynamik* der Interaktionskontexte im *System der Befriedigung menschlicher Bedürfnisse* gerecht zu werden, führen zu Problemen in einem solchen System. Wenn alle Kontexte gleich behandelt werden, führt dies dazu, dass viele Menschen in unterschiedlichem Maße davon ausgeschlossen werden, von den gestalteten Dingen zu profitieren, und folglich werden ihre Bedürfnisse nicht oder nur teilweise erfüllt. Ausgrenzung durch Design „stellt die extreme Reaktion auf schlechtes Design dar, das viele Menschen frustriert oder in Schwierigkeiten bringt, selbst wenn sie nicht ausgeschlossen sind“ (Clarkson, J.: 2007, S. 178). Viele Einzelpersonen, Gruppen und Gesellschaften sind in Bezug auf *Nutzbarkeit* und *Zugänglichkeit* durch *Design ausgegrenzt* worden, so dass ihre Bedürfnisse nicht erfüllt werden konnten.

Die Bewertung (Beschreibung, Analyse und Interpretation) des Phänomens im Hinblick auf die vorgeschlagene Ursache hat dazu beigetragen, dem Wissensfundus neue verifizierte und verallgemeinerte *theoretische Erkenntnisse* hinzuzufügen (Wissen – was, wie und warum). Es kann wertvoll sein und zur Erweiterung des wissenschaftlichen Wissens beitragen und somit zu einem umfassenderen und tieferen Verständnis des Phänomens führen. Dieses Wissen zeigt sich in der genauen Anatomie der Beziehungen zwischen Individuum und gestalteter Sache in Bezug auf Nutzung und Zugang, in der tiefgreifenden Klärung der dynamischen Vielfalt der Kontexte der Menschen, in der genauen Beschreibung der sozial nicht nachhaltigen Ergebnisse unseres gegenwärtigen Designparadigmas (*Designexklusion*) und in der Bestätigung der vorgeschlagenen Ursache in Bezug auf die Designpraktiken hinter dem Phänomen.

Im Lichte dieser *Erkenntnisse*, um das Phänomen in die Zukunft zu *projizieren* und zu versuchen, es zu kontrollieren und anzupassen, hat die Studie an der Strukturierung und Etablierung neuer geeigneter elaborativer Ansätze gearbeitet – die Ansätze "*Design für gleiche Nutzbarkeit (usability)*" und "*Design für gleiche Zugänglichkeit (accessibility)*" als Hauptbestandteile des *gerechten Designansatzes* – um das *optimale Modell des nachhaltigen Designs* zu unterstützen. Beide Ansätze stellen das *herkömmliche Design-Paradigma* in Frage, das auf das Modell des *Durchschnittsfalls* oder auf *bestimmte* Personen, Gruppen oder Gesellschaften abzielt, und bemühen sich um *Inklusivität* und *Praktikabilität*. Bei beiden Ansätzen werden verschiedene Wege beschritten, um sicherzustellen, dass alle Menschen das finden, was für die Teilnahme an den Aktivitäten des täglichen Lebens, die Erledigung von Aufgaben und die Befriedigung ihrer menschlichen Bedürfnisse nutzbar und zugänglich ist. Außerdem wurden für jeden Ansatz einige *grundlegende Schlüssel* strukturiert und festgelegt, um das Bewusstsein zu schärfen, das für die Verbreitung seiner Botschaft innerhalb der *Design-, Geschäfts- und Entscheidungsgemeinschaft* erforderlich ist.

Dieses strukturierte und etablierte *projektive Wissen* (Wissen – was getan werden sollte und wie) kann wertvoll und anwendbar sein, wenn es darum geht, *Designexklusion* zu vermeiden und die dringenden und komplexen Probleme einer Welt anzugehen, die sozial nicht nachhaltig ist. Außerdem kann es zur Erweiterung wissenschaftlicher Erkenntnisse beitragen, die wiederum die neuen Designpraktiken leiten, um die *Agenda der Nachhaltigkeit* in Bezug auf die *soziale Gerechtigkeit bei der Befriedigung menschlicher Bedürfnisse anzugehen – Gerechtigkeit innerhalb der Generationen* – und den Weg für eine sozial nachhaltige Gestaltung der Zukunft der Menschheit zu ebnen.

Zusammen können das *theoretische* und das *projektive Wissen* effektives Wissen liefern, das für die Verfeinerung der *Designtheorie* von Wert sein kann und uns in die Lage versetzt, auf neue Weise über Design nachzudenken und die neuen Designpraktiken anzuleiten, um *sozial nachhaltiges Design* zu produzieren.

Verfahren und Methode dieser Studie folgen dem *deskriptiv kausalen* und dem *projektiv normativen* Ansatz. Sie kann entsprechend ihrer *Art* und der zugrunde *liegenden Motivation* (Zweck der Studie) als *theoretische* (grundlegende) und *projektive* Studie klassifiziert werden. Bei der Datenerhebung wurde auf das Instrument der *indirekten Beobachtung* zurückgegriffen, und bei der Verarbeitung der Daten wurde die *qualitative Analysemethode induktiv*, *deduktiv* und *abduktiv* angewandt.

Abstract

The world exists in a *socially unsustainable* state. Conditions of *social inequity* in meeting *human needs* have exceeded the limit. This state has taken place in the same society and across different populations, and its results have become classic *wicked problems*. Such conditions 'are a result of the assumptions of utilitarian philosophy underlying mainstream economics, which is indifferent to the risk of very bad outcomes for some individuals in the present or everyone in some alternative futures' (Dresner, S.: 2008, p. 4).

This state has been inextricably linked to *design*. Simply, it could be acknowledged that there's a correlation between the state of design (*design paradigm*, *studies* and *research* guiding *design practices*) and the state of the world through recognizing the role of design in *meeting human needs*. The foremost intent of design is the satisfaction of human needs (Margolin, V.: 2002, p. 25). Accordingly, the *socially unsustainable* state of the world implies that there's a defect in the past and current *design practices*; and that the current various forms of design paradigm, studies and research don't do a good job in guiding the practices to be sustainable.

Unfortunately, in the dominant system – *production for the market*, most professional design practices serve via commerce and commercialism (Chick, A.: 2011, p. 70) whose primary purpose of *design for the market* is creating designed things for *profit* (*self-interest*). Actually, design is shackled to other goals and values rather than its real ones; 'increasingly design, as a service, acts on instructions rather than taking action in the original sense' (Fry, T.: 2009, p. 25) or according to its own theory. It lost its free will and its ability to control. Driven by serving the commercial brief, it 'serves an instrumental mode of making that brings things to being without knowing what the consequences will be' (ibid.: p. 26).

This study has examined the phenomenon '*the correlation between design and the social unsustainability state of the world*' to discover deficiencies in the past and current *design practices* behind this state, and accordingly, put forward suitable elaborative approaches for avoiding the recurrence of this phenomenon.

The study has proved and acknowledged that *unequal design practices* or *not deeply considering the dynamic diversity of people's contexts characteristics in design practices* (*design exclusion*) is a verified main cause behind this phenomenon. This has been achieved via collectively evaluating the interaction effectiveness within *individual-designed thing relations of access and use* through which *equitability* could be achieved, or via evaluating how *equitable accessibility* and *usability* of designed things are across people.

The dominant design paradigm driven by serving the commercial brief is most fundamentally formulated as a reduction of variety. It adopts the *average case* model (the average user or the standard environment) or targets specific people, groups or societies. Inflexible design models lacking a variety

of actions to fit the *diversity* and *dynamism* of interaction contexts in the *system of meeting human needs* create troubles in such a system. Treating all contexts as the same leads to excluding to varying degrees many people from benefiting from the mainstream designed things, and consequently, their needs aren't partially or completely met. Exclusion by design 'represents the extreme reaction to poor design which leaves many frustrated or facing difficulty, even if not excluded' (Clarkson, J.: 2007, p. 178). Many individuals, groups and societies have been vulnerable to *design exclusion* regarding *usability* and *accessibility*, and consequently, their needs haven't been met.

Evaluating (describing, analyzing and interpreting) the phenomenon according to the proposed cause has helped add new verified and generalized *theoretical knowledge* (knowing – what, how and why) to the body of knowledge. It may be of value and may contribute to the growth of scientific knowledge and thus achieve a more comprehensive and deeper understanding of the phenomenon. This knowledge is represented in the accurate anatomy of the individual-designed thing relations of use and access, the deep clarification of the dynamic diversity of people's contexts, the accurate descripttion of the socially unsustainable results of our current design paradigm (*design exclusion*), and the confirmation of the proposed cause related to design practices behind the phenomenon.

In light of this *knowledge*, for *projecting* the phenomenon future and trying to control and adjust it, the study has worked on structuring and establishing new suitable elaborative approaches – the *design for equal usability* and *design for equal accessibility* approaches as main parts of the *equitable design* approach – for supporting the *optimal model of sustainable design*. Both approaches challenge the *conventional design paradigm* adopting the *average case* model or targeting *specific* people, groups or societies, and work to ensure *inclusiveness* and *practicality*. For each approach, diverse *paths* have been introduced to ensure that all people find what is useable and accessible for participating in daily life activities, achieving tasks and satisfying their human needs. Also, for each approach, some *fundamental keys* have been structured and established for raising awareness needed to promote its message within the *design, business and decision-making communities*.

This structured and established *projective knowledge* (knowing – what should be done, and how) may be of value and applicably useful in helping avoid *design exclusion*, and tackle the pressing and complex problems of a world made socially unsustainable. Also, it may contribute to the growth of scientific knowledge, which in turn guides the new design practices to address the *agenda of sustainability* regarding *social equity in meeting human needs – equity within generations* – and pave the way for shaping humans' future in a socially sustainable fashion.

Together, the *theoretical* and the *projective knowledge* may provide effective knowledge that may be of value in refining the *design theory*, and enable us to think about design in new ways and guide the new design practices to produce *socially sustainable design*.

According to the applied *procedural method*, this study follows the *descriptive*, *causal* and *projective normative* studies. It can be classified according to its *nature* and *underlying motivation* (purpose of study) as a *theoretical* (basic) and *projective* study. For data collection, it has relied on the *indirect observation* tool; and for processing the data, it has used the *qualitative analysis* method *inductively*, *deductively* and *abductively*.

Contents

List of Figures

List of Tables

List of Abbreviations

AFA	Alzheimer Foundation of America
AfH	Architecture for Humanity
AHFE	Applied Human Factors and Ergonomics
AMD	Age-related Macular Degeneration
CAPMAS	Central Agency for Public Mobilization and Statistics – Egypt
CDC	Centers for Disease Control and Prevention
CSR	Corporate Social Responsibility
CUD	Center for Universal Design
DAN	Design for Ageing Network
DBA	Design Business Association
DfA	Design for All
DTI	Department of Trade and Industry
DTV	Digital Terrestrial Television
EIDD	European Institute for Design and Disability
FCA	Family Caregiver Alliance
GDP	Gross Domestic Product
GNP	Gross National Product
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HGP	Human Genome Project
HLL	Hindustan Lever Ltd.
IAUD	International Association for Universal Design
ICERD	International Convention on the Elimination of All Forms of Racial Discrimination
ICF	International Classification of Functioning, Disability and Health
iDE	International Development Enterprises

IDeA	Inclusive Design and Environmental Access
IDRC	Inclusive Design Research Centre
IFC	International Finance Corporation
IHCD	Institute for Human Centered Design
ISO	International Organization for Standardization
LGN	Lateral Geniculate Nucleus
MDGs	Millennium Development Goals
MNCs	Multinational Corporations
MS	Multiple sclerosis
MT	Movement Time
NCSU	North Carolina State University
NEI	National Eye Institute
NFP	Not-for-profit
NFPs	Not-for-profit Organizations and Institutions
NHS	National Health Service – England
NIDCD	National Institute on Deafness and Other Communication Disorders
NIDRR	National Institute on Disability and Rehabilitation Research
NINDS	National Institute of Neurological Disorders and Stroke
NGOs	Non-governmental Organizations
NPD	New Product Development
OCAD U	Ontario College of Art and Design University – Toronto, Canada
OLPC	One Laptop per Child
PD	Participatory Design
R&D	Research and Development
RCA	Royal College of Art
RT	Reaction Time
SNHL	Sensorineural Hearing Loss
SPL	Sound Pressure Level
SRD	Socially Responsible Design

UCD	User-Centred Design
UD	Universal Design
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
USCB	United States Census Bureau
WB	World Bank
WCED	World Commission on Environment and Development
WHO	World Health Organization
CEDAW	Convention on the Elimination of All Forms of Discrimination Against Women

1. Introduction

1. Introduction

1.1. Background:

Unfortunately, our world has been vulnerable, and we virtually exist in a state of *unsustainability*. The extent and speed of negative changes to humans' quality of life and the global environment are astounding. Social inequity (regarding meeting human needs) and environmental degradation and their results[1] have been classic *wicked problems*[2] (Marshall, T.: 2008, Wicked problems, p. 447). They have become more complicated, overlapping and universal; and their scale is evidently still growing – some of this will be clarified throughout this thesis. Frequently, the media predicts bad and painful scenarios regarding our present and future.

1.1.1. State of the world:

Briefly, the state of the world could be clarified via:

- **The status quo of social equity – Equity within generations:**

Today, we are faced with a dramatic increase in collective pathologies of societies resulting from unmet human needs. 'Every system creates in its own way obstacles to the satisfaction of one or more needs' (Max-Neef, M.: 1991, p. 22). The status quo of meeting human needs implies that 'there are billions of people in abject poverty living in conditions where improving quality of life …., and thereby the potential for human development, remains a considerable challenge' (Fuad-Luke, A.: 2009, p.55).

[1] For example, unmet human needs can result in diverse ailments such as famines, diseases, high mortality rates, exposure to extinction, physical danger reaching to death, homelessness, unsettlement, migration, unemployment, loneliness, social anxiety, clinical depression, loss of affiliation, inferiority, weakness, helplessness, addiction, crime, suicide, ignorance, loss of personal identity and others.

[2] *Wicked problems* is a phrase first coined in 1973 by Horst Rittel and Melvin Webber, theorists of design and social planning, respectively (Marshall, T.: 2008, Wicked problems, p. 447). A wicked problem is a symptom or result of multiple, contingent, and conflicting issues (ibid.). So, it's a complex matter with multi-dimensional, overlapping challenges.

Eighty percent of the world's population still struggles to maintain a quality of life due to their contexts characteristics which hamper their abilities to *access* what meets their needs (access the mainstream satisfiers and designed things). They are subject to food shortages, vagaries of variable potable water supply, poor sanitation, disease, homelessness, unsettlement and migration, conflicts (due to resources shortage), poor healthcare systems and poor education systems, often coupled with socio-economic and political instability. Therefore the majority of people are classified as *under-consumers* – they actually need to consume more to elevate their very basic standard of living. On the contrary, the remaining 20% of the world are *over-consumers*, they use approx. 83% of the world's resources, a situation that most societies would recognize as grossly unfair. Actually, the basic human needs – *physiological and safety needs* as envisaged by Abraham Maslow or *subsistence needs* as framed by Manfred Max-Neef, in their respective needs typologies – are met for this global minority. (ibid.: p 55, 56)

In addition to the *under-consumers*, there are others whose human needs aren't met or find difficulties in meeting their human needs due to their contexts characteristics which hamper their abilities of *use* or *harmony with* what meets their needs (of using or harmonizing with the mainstream satisfiers and designed things).

This state of the absence of social equity takes place in the same society and across different populations. Throughout this research, many statistics and examples regarding individuals, groups, people segments and societies whose needs aren't met or who find difficulties in meeting their needs will be extensively mentioned – see sections 2.1, 2.8, 3.1 and 3.5.

Overall, this informs us about the *unsustainability state of the world in regards to meeting the human needs of the present people*, and about why we are faced with a dramatic increase in collective pathologies. Not meeting their own needs, particularly basic ones, means that humans wouldn't be able to sustain themselves, thus the future of humankind is in danger.

- **The status quo of the environmental quality – Equity between generations:**

Excessive exploitation of our planet resources for human activities has resulted in the depletion of resources, reduction of biodiversity and land degradation; and exceeding the level of emissions due to such activities has led to global warming (climate change), ozone layer depletion, eutrophication, acidification, smog, toxic emissions (water, air and soil pollution) and solid waste (Vezzoli, C.: 2008, p. 54 and Lewis, H.: 2001, p. 100). 'All trends point to a deterioration of the life-giving support provided by global ecosystems' (Fuad-Luke, A.: 2009, p. 55), which have lost their stability to sustain themselves and consequently their abilities to serve humans to sustain themselves. In turn, this negatively affects the ability of future generations to meet their own needs.

This state could be attributed to the sum of human activities via which humans satisfy their different needs, depending on the ecosystems services. These activities are inextricably linked to our current *systems of production and consumption* and their excessive use of resources and energy and their excessive emissions. While production provides designed things that empower what satisfies people's needs, consumption of such things works as fuel for the process of satisfying their needs.

To highlight the evidence and extent of human activities that have had a significant global impact on the Earth and atmosphere, including to what extent the historical geology of the Earth has changed; the geologic chronological term *anthropocene* has appeared to light. It was coined by the ecologist Eugene F. Stoermer and the Nobel Prize-winning atmospheric chemist, Paul J. Crutzen in 2000. They indicated that '…… it seems to us more than appropriate to emphasize the central role of mankind in geology and ecology by proposing to use the term anthropocene for the current geological epoch.'[1] (Crutzen, P.: 2000, p. 17)

Conclusion: Obviously, the world exists in a state of *unsustainability* according to these conditions of absent *social equity in meeting human needs* and low *environmental quality*. Both conditions 'are a result of the assumptions of utilitarian philosophy underlying mainstream economics, which is indifferent to the risk of very bad outcomes for some individuals in the present or everyone in some alternative futures' (Dresner, S.: 2008, p. 4). Building on the theories of the philosopher John Rawls, Simon Dresner (2008) suggested that there are very severe tensions between the utilitarian basis of mainstream economics and sustainability's concern for equity within and between generations (ibid.).

[1] They proposed the latter part of the 18th century to be the onset of *anthropocene* because, during the past 2 centuries, the global effects of human activities have become noticeable. This is the period when data retrieved from glacial ice cores show the beginning of a growth in the atmospheric concentrations of several greenhouse gases, in particular CO2 and CH4. Such a starting date also coincides with James Watt's invention of the steam engine in 1784. Around that time, biotic assemblages in most lakes began to show large changes. (Crutzen, P.: 2000, p. 17)

1.1.2. Correlation between the state of design and the state of the world:

Easily, it could be acknowledged that there's a correlation between the state of design and the state of the world through recognizing the design role in *meeting human needs* and *environmental quality*. Regarding *meeting human needs*, 'design is understood as a means of responding to human need' (Herling, C.: 2008, p. 267); the foremost intent of design is the satisfaction of human needs (Margolin, V.: 2002, p. 25) via developing designed things (*products*, *services*, *systems*, *environments* and *technologies*) which empower what meets or satisfies these needs directly or indirectly[1]. Briefly, design nurtures the process of actualizing human needs. Regarding *environmental quality*, design practices have an effective role in the amount of human activities[2] impact (consume resources and produce emissions) on the environment and consequently the state of the world in 2 ways, directly, via its main role in the production system of developing designed things; and indirectly, via its contribution to the patterns of consumption.

Thus, there's a correlation between the state of design (design paradigm, studies and research guiding *design practices*) and the state of the world. *This is our fact* – an effect/ consequence fact**.** This is consistent with what Tony Fry pointed out in his book *Design Futuring – Sustainability, Ethics and New Practice* that 'the "state of the world" and the state of the design need to be brought together' (Fry, T.: 2009, p. 4).

1.1.3. Design practices as a convict:

According to the fact that there's a correlation between the state of design and the state of the world; the rampant *unsustainability* state of the world implies that there's a defect in the past and existing *design practices*. This is the phenomenon under study. This shows that the current various forms of design paradigm, studies and research don't do a good job in guiding the practices to be sustainable.

---

[1] Directly as a means of providing a designed thing and by using, consuming or having it, a need could be actualized, e.g. a house for the need of protection. Indirectly as a means of providing other designed things by which a designed thing could exist, e.g. construction equipments are used for the existence of houses that meet the need of protection.

[2] Doing something is an activity that means performing, generating or achieving a certain task or action. For an individual, activity is defined as the execution of a task or action by an individual (WHO: 2001, p. 10, 213). Human activities (doing tasks) are countless and they cover the full range of life areas from basic learning (e.g. learning to read and write) to composite areas such as social tasks (e.g. recreation and leisure, religion and spirituality, human rights, political life and citizenship). For more, see the appendix '*Human life areas and human activities*' or see (ibid.: pp. 39: 42 and pp. 125: 170).

> *By focusing its energies on production and sales while neglecting to address the need for a solid socio-theoretical substructure, design as a discipline has been stuck for years in a crisis of positioning and meaning. In order to regain social relevance, there has to be an effort to establish a design theory that addresses economic, social and cultural considerations and also identifies and addresses the weaknesses and failures of design in those contexts.* (Haslinger, S.: 2008, p.367)

We have to acknowledge the bad consequences of our past and current *design practices*, but design practitioners must go beyond this by challenging our understandings of designed things, and reframing our conceptions of designed things. (Walker, S.: 2006, p. 3)

The past few decades have witnessed increased criticism and accusations toward design practices regarding their bad unsustainable outcomes and so toward their related actors. Danger has exceeded the limit. This reflects the failure to face the *wicked problems* prevailing in our world and doesn't agree with the hopes and aspirations of *sustainability* for human beings. So, strong calls for great changes are always attendant.

The criticism toward design practices regarding absent *social equity in meeting human needs* and low *environmental quality* isn't recent; it extends from the sixties of the 20th century. The difference is that the criticism in the last 3 decades has arisen under the concepts of the wide, most refined term – *Sustainability*.

1.2. The critical refined term – Sustainability:

'*Sustainability* is a measure of the resilience of a system, the capacity of a system (and all its components) to repair itself when damaged' (Tonkinwise, C.: 2008, p.380). It's the ability of a system to constantly exist without effective disturbances. Regarding the humans' system, 'in the 21st century, it refers generally to the capacity for the biosphere and human civilization to coexist' (World Design Organization (WDO)[1]). It's also defined as the process of people maintaining homeostasis and balance in a changing environment, in which the exploitation of resources, the level of emissions, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations[2].

[1] wdo.org/glossary/sustainability/

[2] globalfootprints.org

> *The term sustainability was hardly heard until the late 1980s, 20 years after the contemporary environmental movement got going.* (Dresner, S.: 2008, p. 1)
>
> *The concept sustainability in something like its modern form was first used by the world council of churches in 1974[1]. It was proposed by western environmentalists in response to developing world objections to worrying about the environment when human beings in many parts of the world suffer from poverty and deprivation. The concept of sustainable development was put forward by the International Union for Conservation of Nature and Natural Resources in 1980[2].* (ibid.)
>
> *Sustainability and sustainable development finally came to prominence in 1987, when the United Nations World Commission on Environment and Development[3], chaired by Norwegian prime minister Gro Harlem Brundtland, published its report* Our Common Future[4]*. The central recommendation of this document, usually known as the Brundtland report, was that the way to square the circle of competing demands for environmental protection and economic development was through a new approach: sustainable development. They defined it as development that 'meets the needs of the present without compromising the ability of future generations to meet their needs'[5].* (ibid.)
>
> *The ecological economist Richard Norgaard has argued that the concept of sustainable development actually marks the beginning of a break by the dominant strand of western culture from an idea it has been firmly wedded to for the past two centuries – faith in progress. When people believed in progress they did not worry about taking care of the environment for the sake of their children and grandchildren. Progress was seen in terms of the mastery of nature. People assumed that advancing science and technology, by increasing human mastery over nature, would decrease our dependence on it. In recent years, faith in human beings capacity to successfully master nature or even to collectively control our own destiny has been diminished.* (ibid.: p. 4)

'Only in the last few decades has widespread doubt set in about the direction that our path of development is taking us' (ibid.: p. 5) – the path depending on Western culture's optimism about science and progress (the capacity of technological progress to substitute for natural resources).

[1] World Council of Churches: 1974, *Report of Ecumenical Study Conference on Science and Technology for Human Development*, Geneva, World Council of Churches.

[2] International Union for Conservation of Nature and Natural Resources: 1980, *World Conservation Strategy: Living Resources Conservation for Sustainable Development*, Gland, Switzerland: IUCN.

[3] – abbreviated as WCED.

[4] WCED: 1987, *Our Common Future*, Oxford: Oxford University Press.

[5] ibid.: chapter 2, note 1, p. 8.

1.2.1. Sustainability and equity:

> *The sustainability debate is not just about 'environment versus growth'. …….. It is really more a question of equity*[1]*. Concern about sustainability must be based on moral obligations towards future generations – not just personal self-interest. A crucial sentence in the Brundtland report stated: 'Even the narrow notion of physical sustainability implies a concern for social equity between generations, a concern that must logically be extended to equity within each generation.'*[2] (ibid.: p. 2)
>
> *They wrote that sustainable development was about both equity between generations and equity within generations* (ibid.: p. 1, 2).
>
> *In the 1990s, environmentalists took up Brundtland's idea of the connection between equity within generations and equity between generations. Using the concept of 'environmental space' many environmentalists now claim that sustainability requires people in the industrialized countries to reduce the consumption of resources per head to a level at which everyone in the world would be able to live on indefinitely.* (ibid.: p. 3)

The commitment to *equity* is crucial to the idea of *sustainability*. Resources have to be shared so that there is enough for everybody – for *equally meeting human needs*, both now and in the future (ibid.: p. 4). *Equity within generations* is via equally meeting human needs – *social equity*; and *equity between generations* is via ensuring good environmental quality – *environmental protection* – for meeting the human needs of future generations.

So, *sustainable development* is an invitation to achieve economic growth but via equally meeting the human needs of the present people without destroying the natural capital (depletion or deterioration of the natural environment) to sustain its ability to meet the needs of the next generations.

1.2.2. Inequity means unsustainability:

Not equally meeting human needs (*inequity within generations*) – especially on the collective level, or causing troubles in the natural capital (*inequity between generations*) means that there are unsustainable practices by the dominant systems, which in turn leads to an unsustainable state of the world.

---

[1] Equity refers primarily to distributive justice (distribution of outcomes, opportunities or capabilities) to avoid unjust inequalities among people. (UNDP: 2011, p. 18, 19)

[2] WCED: 1987, op cit, p.43.

'Inequitable processes are unjust, whether across groups or generations. Inequalities are especially unjust when they systematically disadvantage specific groups of people ......, or when the gap is so great that acute poverty is high. The current generation's destroying the environment for future generations is no different from a present-day group's suppressing the aspirations of other groups for equal opportunities to jobs, health' (UNDP: 2011, p. 19), education or broader political freedoms.

Inequality regarding equal opportunities creates many health and social problems; and consequently, unhappy and unhealthy societies. By using income inequality as an evident example, Richard Wilkinson and Kate Pickett examined the apparently life-diminishing results of internal inequality within societies in their controversial book *The Spirit Level: Why Equality is Better for Everyone*. 'Their analysis of social trends in 23 economically developed countries finds that inequality of income within those societies seems to be reflected in shorter, unhealthier and unhappier lives for all members of those societies, not just the poorest' (Chick, A.: 2011, p. 145). Indeed, societies with a bigger gap between rich and poor are bad for everyone in them, incl. the well-off (Wilkinson, R.: 2009). 'They find evidence for direct relationships between inequality and health (particularly mental health) and social problems. Hyper-consumerism, isolation, alienation, social estrangement and anxiety in all sectors of the community are apparently linked to the inequality found in economically developed nations' (Chick, A.: 2011, p. 145). The analysis provides hard evidence to show how almost everything from life expectancy to depression levels, violence to illiteracy, is affected not by how wealthy a society is, but how equal it is (Wilkinson, R.: 2009). The analysis suggests that the economic income of a nation isn't 'a reliable indicator of its overall well-being. Equal distribution of wealth, rather than overall wealth, creates a well society. The difference between a nation's rich and poor is more important than the difference between that nation's wealth and the wealth of other nations' (Chick, A.: 2011, p. 145).

The most disadvantaged people, groups or populations, whose needs are unmet compared to others, carry a double burden: one from *deprivation of meeting their needs*, and one from the state of *inequity in meeting such needs* at least in the same society. Not meeting human needs means creating many pathologies, and its accompanying *inequity* results in many more.

1.3. How are designed things sustainable? How is design sustainable?

As mentioned before, there's a correlation between the state of design (design paradigm, studies and research guiding *design practices*) and the state of the world, and *this is our fact*. For a sustainable world, design must also be sustainable, but how?

Principally, there's a set of qualities that should be considered to ensure the existence of a designed thing. Such a set includes *functionality*, *accessibility* (incl. *affordability*), *usability* and *harmonizability* (incl. *aesthetics*). To be sustainable – economically, socially and environmentally, qualities of *viability/profitability*, *equitability* and *environmental quality* should be adequately considered while designed things are being developed. They represent the 3 dimensions of *sustainability* respectively: *economic development*, *social equity in meeting human needs*, and *environmental friendship*. In an *optimal model of sustainable design*, a designed thing could be considered successfully sustainable when it's economically, socially and environmentally sustainable; or when it's *functional*, *equally accessible*, *equally usable*, *equally harmonizable*, *viable*, and *environmentally friendly* – fig. 1.1.

Functional: A functional designed thing means that it can fulfill the purpose for which it serves/is created, based on the behaviour given by its specific structure (Aranda-Jan, C.: 2016, p. 45).

Accessible: An accessible designed thing for an individual means that he/she has the ability, right or permission to get to it, or that access-related characteristics of his/her context are considered.

Usable: A usable designed thing for an individual means that he/she can physically interact with it easily or that use-related characteristics of his/her context are considered.

Harmonizable: A harmonizable designed thing for an individual means that it agrees with his/her intellectual dimensions or that harmony-related characteristics of his/her context are considered.

Viable: The business success of a designed thing can be measured by its profitability. This typically results from having a designed thing that is functional, accessible, usable, and harmonizable, and which is delivered to the market at the right time. (Coleman, R.: 2007, Intro., p. 1-12)

Equitable: While developing a designed thing, equitable design practices are those ensuring that all people find what is useable, accessible and harmonizable regardless of their different contexts for equally satisfying their human needs.

Environmentally friendly: An environmentally friendly designed thing means that it doesn't have any negative environmental impact across its life from material extraction through to eventual disposal.

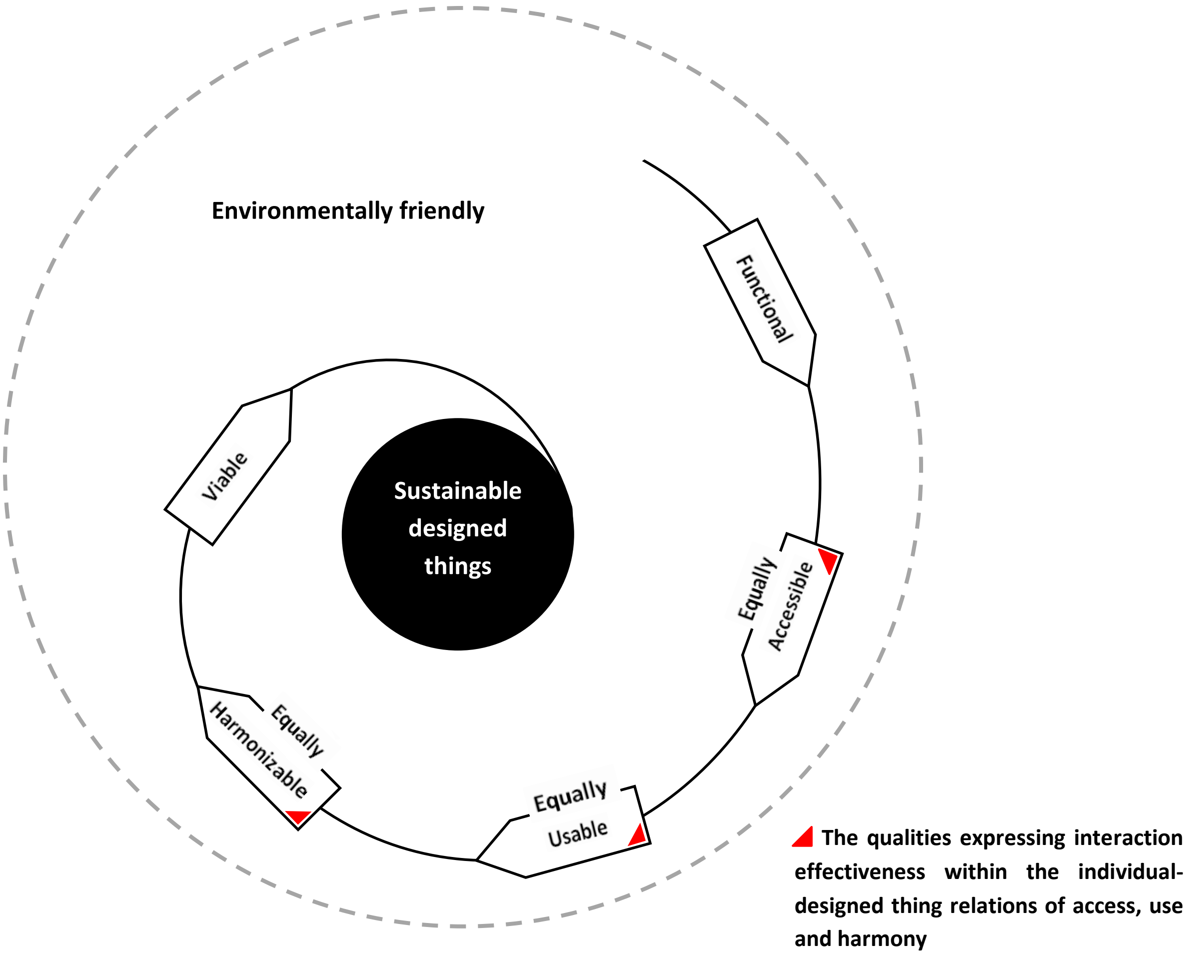


Fig. 1.1: A simple optimal model of sustainable design. It considers all qualities leading to socially, environmentally and economically sustainable designed things.

The qualities of *accessibility*, *usability* and *harmonizability* express interaction effectiveness within the *individual-designed thing relations of access, use and harmony* respectively. Also, they are qualities through which *equitability* could be achieved – fig. 1.1. Here are the definitions of the 3 qualities:

- **Accessibility** is the extent to which a designed thing can be accessed by specified persons to achieve specified goals. It refers to *the possession level of ability, right or permission to get to it*.
- **Usability** is the extent to which a designed thing can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified performance environment (ISO 9241-11: 1998). It refers to *the ease level of physical interaction between the users and the designed thing they use*.
- **Harmonizability** is the extent to which a designed thing can be harmonized with specified recipients to achieve specified goals. It refers to *the intellectual agreement level between the recipients and the designed thing*.

The levels of accessibility, usability and harmonizability are directly proportional to the levels of *pleasurability*, and in turn to the levels of *acceptability* and *desirability* of an individual toward a designed thing. Adequate ability levels of access, use and harmony with a designed thing positively affect the relative kind of pleasure. Easily accessible, usable or harmonizable designed things are pleasurable, while those that place unnecessarily high demands on the person will cause frustration for many people and exclude some altogether. Frustration with, or inability to interact with a designed thing can convince people that they are no longer able to lead an independent life (Coleman, R.: 2007, Intro., p. 1-12). The emotions resulting from the ability levels of accessing, using and harmonizing with a designed thing could be respectively classified as *access-*, *use-* and *harmony-induced emotions*. Thus, a designed thing may be acceptable and desirable for many reasons, including being easy to use, conferring social status, being aesthetically striking or pleasant to touch, or providing a positive impact on the quality of life (ibid.).

Also, according to the above definitions, the relationship between *accessibility* and *usability* becomes clear, and continuing to use them as synonyms becomes totally unacceptable. Such definitions acknowledge that *accessibility* is a fundamental prerequisite of *usability*; i.e. the *individual-designed thing relation of access* is a prior phase to the use relation, and there may not be use interaction if there's no possibility of interaction in the 1st place (Stephanidis, C.: 2009, Universal access and design, p. 1-3). Previously, *accessibility* frequently meant enabling the use of a designed thing for people with *defects in the body functions*/abilities or with special needs; or enabling the use of a designed thing via depending on *assistive technology*.

1.4. Socially responsible design (SRD):

The previous qualities can easily lead to structuring specific areas of the social responsibility of design (social role of design), and in turn, to creating a clear model of *SRD*. According to such qualities, the proposed model consists of 4 areas: *meeting human needs*, *equity in meeting human needs*, *environmental friendship*, and *profits* – fig. 1.2.

1. **Meeting human needs:** the qualities of *functionality*, *accessibility*, *usability* and *harmonizability* reflect the social responsibility of design in fulfilling a need. To meet human needs via designed things is a social matter whatever the kind of needs. This demonstrates the *noble social role* of design.
2. **Equity in meeting human needs (social inclusion):** the quality of *equitability* reflects the social responsibility of design in equally fulfilling a need through designed things via ensuring that all people find what is useable, accessible, and harmonizable regardless of their different contexts for equally satisfying their human needs. To be equal in meeting human needs, or to avoid exclusion or frustration of individuals, groups and populations whatever their contexts characteristics, is a social matter.
3. **Environmental friendship:** the quality of *environmental quality* reflects the social responsibility of design in avoiding negative environmental impacts of designed things across their life – from material extraction through to eventual disposal. The aim is to maintain the stability of ecosystems to keep sustaining themselves and consequently sustain their abilities to serve the current and future generations to sustain themselves.
4. **Profits:** the quality of *viability/profitability* reflects the social responsibility of design in helping maximize shareholders' wealth, or increase business profits.

Thus, design practices could be considered *socially responsible* when they cover the 4 proposed areas or when their outcomes are sustainable.

Fig. 1.2: An illustration shows the *proposed model* of *socially responsible design (SRD)* based on the qualities required for sustainable designed things, and consisting of 4 areas (*meeting human needs*, *equity in meeting human needs*, *environmental friendship*, and *profits*).

Recently, *an area of SRD has emerged*. Design has been acknowledged by public agencies and non-governmental organizations (NGOs) as one of the tools to tackle the most pressing issues and the complexity of social issues (Emilson, A.: 2011, p. 24) – the *wicked problems*, such as environmental degradation and growing social and economical inequality (poverty, unemployment, Illiteracy, etc.). Design has been asked to play a new role and designers have been invited to exploit their unique *design thinking* skills for working on major societal challenges, sometimes in conjunction with, but often regardless of, outside, and even against the market. As it will be clarified later; it hasn't been attractive enough for the dominant system of business within which the majority of designers have been serving. Tragically, capitalists have implicitly assumed that the markets will be served by the corporate sector, while governments and NGOs will tackle the *wicked problems*; this implicit divide is stronger than most realize, and we all suffer from this historical division of roles (Prahalad, C.: 2002, p. 14). Actually, the participation of design in tackling the *wicked problems* is weak and still may remain so, as long as such issues aren't in the circle of business attention – fig. 1.3.

But, is there a possibility to embrace such an area in the proposed model of SRD to ensure that it will be in the circle of attention of business, thus of design practices?

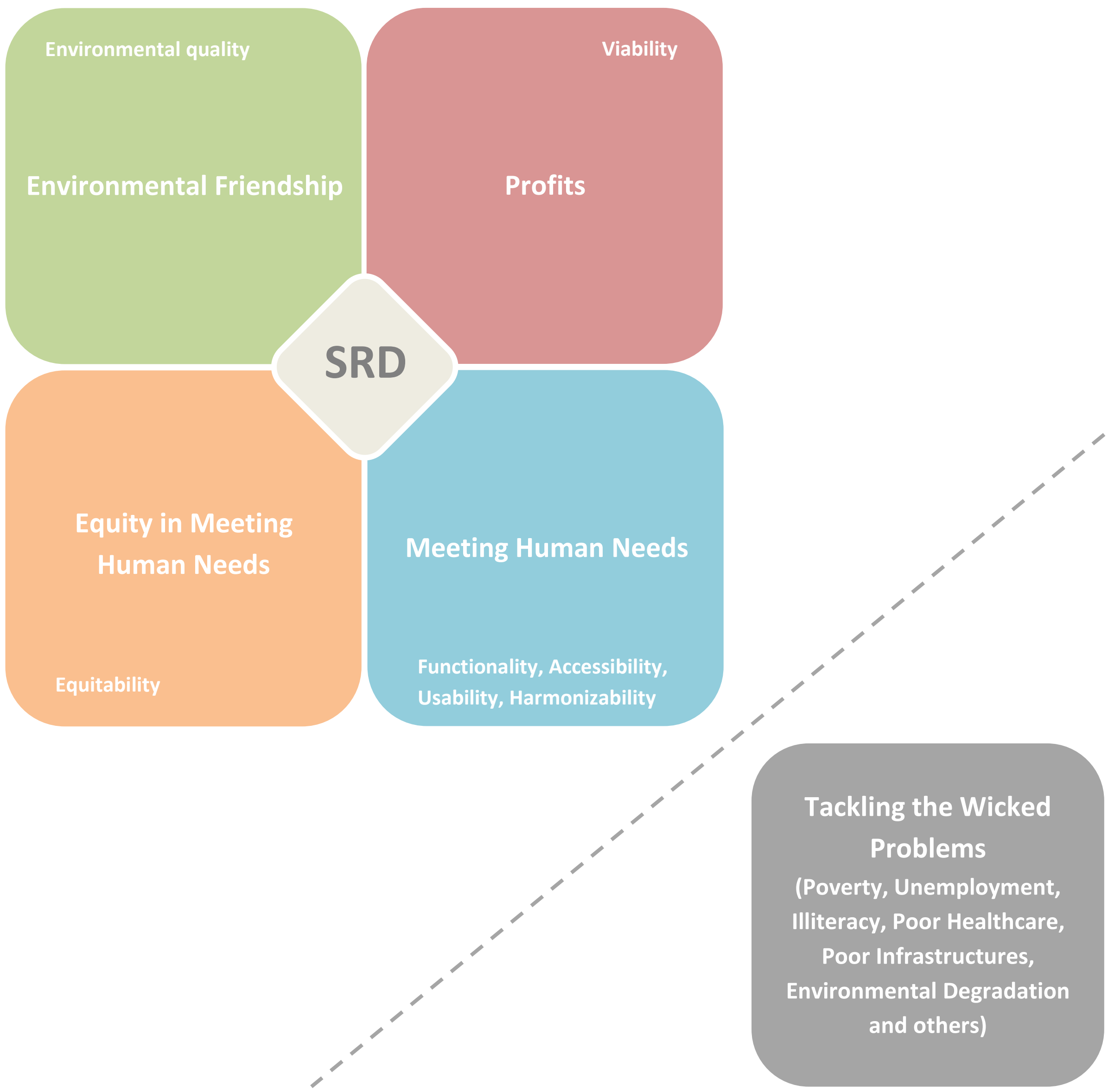


Fig. 1.3: The *new area* of *socially responsible design (SRD) – tackling the wicked problems* – finds difficulties in joining the model because it's still not in the circle of business attention, thus of design practices.

1.5. Other key terms:

To logically navigate within this study, this would first require shedding light on *human needs* and their classifications, the relation between designed things and what meets human needs (*satisfiers* – ways of meeting needs), and the *contextual factors*.

1.5.1. Human needs:

'The word *need* describes a feeling of lack and the longing to satisfy it' (Herling, C.: 2008, p. 267). It's either an inherent natural need or a need by coercion against will or nature – one may imagine pressure exerted by one's peers or the force of advertising including a need to buy things (Boradkar, P.: 2010, p. 161). Most attempts tend to broadly classify human needs into 2 dominant segments: basic necessities (survival needs) and unnecessary luxuries (status needs) (ibid.: p. 160).

1.5.1.1. Classifications of human needs:

1- Maslow's hierarchy of human needs: It's the most known and frequently quoted common and popular classification of human needs. The psychologist Abraham Maslow proposed it in 1943 in a paper called *A Theory of Human Motivation* (Boradkar, P.: 2010, p. 164), and expressed the full theory in his book *Motivation and Personality* (1954). The theory was 'a way of attempting to understand what motivates people in their actions and goals' (Chick, A.: 2011, p. 146). He stratified human needs from the lower to the higher, the physiological to the cognitive/spiritual, or the material to the non-material (Boradkar, P.: 2010, p. 164) according to the following types and levels: *physiological*, *safety*, *belongingness and love*, *esteem*, and *self-actualization needs*. Later, *Maslow's hierarchy of human needs* is often portrayed in the shape of a pyramid with the largest, most fundamental levels of needs at the bottom and the need for self-actualization at the top – fig. 1.4.

Maslow theorized that human beings are motivated by unsatisfied needs and that certain lower needs need to be satisfied before higher needs can be satisfied; a person couldn't recognize or pursue the next higher need in the hierarchy until his/her currently recognized need is substantially or completely satisfied. When all of the foregoing needs are satisfied, then and only then is the need for the higher one activated, a concept called *prepotency*. 'Human needs arrange themselves in hierarchies of pre-potency. That is to say, the appearance of one need usually rests on the prior satisfaction of another, more pre-potent need' (Maslow, A.: 1943, p. 370).

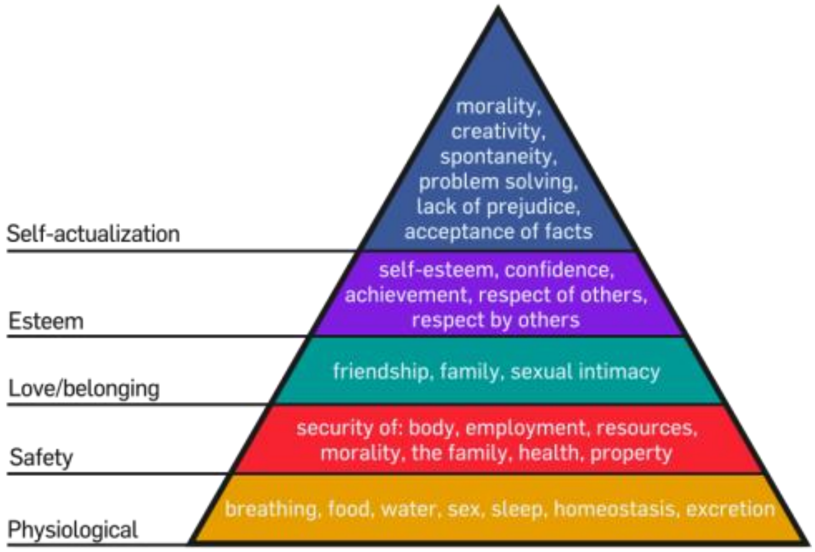


Fig. 1.4: The common pyramidal representation of *Maslow's hierarchy of human needs*, represented as a pyramid with the more basic needs at the bottom. (Wikipedia: Hierarchy of needs)

Regardless of the criticism of Maslow's theory due to its proposed hierarchy of human needs categories and the obligatory satisfaction of the lower categories before activating the higher one, its classification of human needs has remained the most important one and has paved the way for other revised ones. In general, this classification helps understand the different types of human needs for which we might be designing (Chick, A.: 2011, p. 146).

2- Human Scale Development: In the middle of 1970s, 'international agencies, concerned with promoting development, have adopted as their criterion for action the satisfaction of so-called basic needs' (Max-Neef, M.: 1991, p. 13). For developing a theory of human needs understandable and operational for development, 3 scholars of different disciplines – the Chilean economist Manfred Max-Neef, the Chilean sociologist Antonio Elizalde and the U.S.-born philosopher of Argentinean parents Martin Hopenhayn – have put forward the concept of *Human Scale Development* in the middle of 1980s. In their book *Human Scale Development: Conception, Application and Further Reflections*, 1991, it was clarified in detail.

The basic postulate of *Human Scale Development* is that 'development is about people and not about objects' (ibid.: p. 16), and it 'is focused and based on the satisfaction of fundamental human needs' to create conditions for a new praxis (ibid.: p. 8). They pointed out that the best development process is that which allows the greatest improvement in people's quality of life, which relies on the possibilities (*satisfiers*, *designed things*) people have to adequately satisfy their fundamental human needs (ibid.: p. 16).

Also, they realized that it requires an indicator for the qualitative growth of people, not indicators of the quantitative growth of objects as those followed in the traditional paradigm – e.g. the gross national product (GNP) (ibid.: p. 16). Their 'development policy aimed at the satisfaction of fundamental human needs goes beyond the conventional economic rationale because it applies to the human being as a whole' (ibid.: p. 23). In fact, using economic indicators such as the GNP and the gross domestic product (GDP) which consider economic gains and losses – expressed in monetary terms – to express the quality of life and well-being, is clearly misleading. For example, Egypt experienced an increase in its GDP between 2003 and 2008[1], nevertheless, poverty, environmental degradation and human rights abuses increased, followed by the Arab Spring in 2011. Should we then say that Egypt is developing? If we only judge by economics, then the answer may be yes – but there are clearly other factors to be considered (Chick, A.: 2011, p. 144).

> *On one crucial point the evidence is compelling and clear: there is much that countries can do to improve the quality of people's lives even under adverse circumstances. Many countries have made great gains in health and education despite only modest growth in income, while some countries with strong economic performance over the decades have failed to make similarly impressive progress in life expectancy, schooling and overall living standards.* (UNDP: 2010, p. iv)

In this book, they argued that:

- The fundamental human needs (the axiological needs) are needs for *subsistence*, *protection*, *affection*, *understanding*, *participation*, *idleness*, *creation*, *identity* and *freedom* (Max-Neef, M.: 1991, p. 17, 30).
- 'Human needs must be understood as a system: that is, all human needs are interrelated and interactive. With the sole exception of the need of subsistence, that is, to remain alive, no

[1] data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2022&locations=EG&start=1961

hierarchies exist within the system. On the contrary, simultaneities, complementarities and trade-offs are characteristics of the process of needs satisfaction' (ibid.: p. 17).

- There's a fundamental difference between *needs* and *satisfiers* of those needs (ibid.: p. 16). 'Food and shelter, for example, must not be seen as needs but as satisfiers of the fundamental need for subsistence; education (either formal or informal), study, investigation, early stimulation and meditation are satisfiers of the need for understanding; the curative systems, preventive systems and health schemes in general are satisfiers of the need for protection' (ibid.: p. 17); and a political order may be a satisfier of the need for participation (ibid.: p. 25). Satisfiers are related to everything that contributes to the actualization of human needs (ibid.: p. 24). 'Satisfiers may include, among other things, forms of organization, political structures, social practices, subjective conditions, values and norms, spaces, contexts, modes, types of behavior and attitudes, all of which are in a permanent state of tension between consolidation and change' (ibid.: p. 24, 25). In general, 'satisfiers are individual or collective forms of being, having, doing and interacting in order to actualize needs' (ibid.: p. 30). Thus, the satisfiers 'define the prevailing mode that a culture or a society ascribes to needs' (ibid.: p. 24).
- Fundamental human needs are finite, few and classifiable, and they are the same in all cultures and all historical periods – they are universal (ibid.: p. 18, 28). 'What changes, both over time and through cultures, is the way or the mean by which the needs are satisfied' (ibid.: p. 18) – satisfiers and consequently their accompanying designed things. 'Whether a person belongs to a consumerist or to an ascetic society, his/her fundamental human needs are the same. What changes is his/her choice of the quantity and quality of satisfiers' (ibid.: p. 18). In other words, 'satisfiers behave in two ways: they are modified according to the rhythm of history and vary according to culture and circumstances' (ibid.: p. 28). Thus, the satisfiers of needs are numerous and subject to change according to the time, place and circumstances. So, satisfiers of the same human need, if determined 'by individuals or groups from diverse cultures and in different historical moments, might vary considerably' (ibid.: p. 30, 31).
- Satisfiers aren't the available designed things (ibid.: p. 24). Designed things are understood as 'which make it possible to increase or decrease the efficiency of a satisfier' (ibid.: p. 25); 'thus altering the threshold of actualization of a need, either in a positive or negative sense' (ibid.:

p. 30). They 'empower satisfiers to meet fully and consistently fundamental human needs' (ibid.: p. 25). Thus, 'while a satisfier is in an ultimate sense the way in which a need is expressed' (ibid.: p. 25), designed things 'are in a strict sense the means by which individuals will empower the satisfiers to meet their needs' (ibid.: p. 25). The satisfiers and designed things 'nurture the process of actualizing needs and reduce the possibilities of frustration' (ibid.: p. 26). Designed things 'behave in three different ways: they are modified according to episodic rhythms (vogues, fashions) and diversify according to cultures and, within those cultures, according to social strata' (ibid.: p. 28).

- Many of the satisfiers can give rise to different designed things (ibid.: p. 31). If we take, e.g. showing different ways of doing (as satisfiers) to actualize the need for understanding, 'we see that it includes such satisfiers as investigating, studying, experimenting, educating, analyzing, meditating and interpreting. These satisfiers give rise to economic goods, relying on the culture and the resources, such as books, laboratory instruments, tools, computers and other artifacts. The function of these goods is to empower the doing of understanding' (ibid.: p. 31).
- The interrelationship between needs, satisfiers and designed things is permanent and dynamic. (ibid.: p. 30)
- Each economic, social and political system adopts different methods (satisfiers) for the satisfaction of fundamental human needs (ibid.: p. 18). In turn, such satisfiers require correlative designed things to effectively work. So, in every system, human needs are satisfied through the generation of different types of satisfiers and their correlative designed things. Thus, design practices are directed and activated according to the attendant system orientations.

1.5.1.2. The noble social role of design – The 1st area of SRD:

From the above, the role of designed things in meeting human needs is clear. They are means to ends, rather than ends in themselves. Thus, design is understood as a means of providing designed things that empower what satisfies human needs – empower satisfiers for meeting fully and consistently fundamental human needs according to the attendant systems. Briefly, design nurtures the process of actualizing human needs. Thus, human needs should be the objectives of the design process. This *fact* demonstrates the *noble social role* of design concerned with *meeting human needs* and forming the 1st area of SRD.

1.5.1.3. Unmet human needs – Poverties and ailments of societies:

In fact, any fundamental human need that isn't adequately satisfied reveals a human poverty – e.g. poverty of subsistence (due to insufficient income, food, shelter, etc.); of protection (due to natural disasters, family violence, childhood abuse, bad health systems, shortage of jobs opportunities, violence, arms race, war, etc.); of affection (due to social rejection on any level, authoritarianism, oppression, exploitative relations with the natural environment, etc.); of understanding (due to poor quality of education); of participation (due to marginalization and discrimination of women, children and minorities); and of identity (due to imposition of alien values upon local and regional cultures, forced migration, political exile, etc.) (Max-Neef, M.: 1991, p. 18, 19). Recognizing such various types of poverty liberates it from its traditional limited concept that refers exclusively to the predicaments of people who may be classified below a certain income threshold (ibid.: p. 18). *Thus, it makes more sense that our treatments should consider poverties or the pluralism of poverty not poverty as it has been known.*

'Poverties are not only poverties. Much more than that, each poverty generates pathologies' (ibid.: p. 18, 19). Any fundamental human need not adequately satisfied generates a pathology (ibid.: p. 22). In general, unmet needs cause tension to the individual, and not meeting them for long periods may lead to frustration and severe tension that may cause psychological pain and can lead to many defensive tricks, which represent reactions through which an individual tries to protect oneself from this frustration. Failure to do so leads to the transition from frustration to stagnation and from there to a final state of apathy, where the person reaches his/her lowest level of self-esteem. (ibid.: p. 19)

With poverty of subsistence (physiological needs), physically one can't function properly, and will ultimately fail; with poverty of protection (safety and security), a man may become liable to physical danger (may lead to death), homelessness, unsettlement, migration, illness, unemployment, etc.; with poverty of affection (love and belonging), participation and idleness/leisure, a man may become liable to loneliness, social anxiety, clinical depression, loss of affiliation and migration; with poverty of esteem – to be accepted, valued and respected by others and by oneself – a man may become liable to an inferiority complex, weakness, helplessness, loss of affiliation and migration; with poverty of understanding, a man may become liable to ignorance and most of the previous pathologies; with poverty of creation and self-actualization, a man may be without a personal identity; and with poverty of identity and freedom, a man may become liable to weakness, helplessness, loss of affiliation and migration.

Famines, diseases, high mortality rate, exposure to extinction, physical danger (sometimes leading to death), homelessness, unsettlement, migration, unemployment, loneliness, social anxiety, clinical depression, loss of affiliation, inferiority, weakness, helplessness, addiction, crime, suicide, ignorance, loss of personal identity and others, are diverse ailments generated by diverse poverties, which, in turn, result from unmet human needs. On the individual and small group level, treatments may be easily developed to face these ailments by providing what meets the related unmet needs. The real complex problem is when these ailments are collective – at a large scale or affect a whole society, the situation is much forked and complex, and requires treatments developed under *transdisciplinary research* and *action* (ibid.: p. 22, 23).

1.5.2. The context – The contextual factors:

Here, the *context* is the set of actual conditions under which a designed thing is interacting with individuals. It's the frame of reference in which a designed thing interacts with its target groups. A context is an integrated frame of all attendant values of the *contextual factors* under which the *designed thing-individual interactions of access*, *use* and *harmony* occur. The 'contextual factors represent the complete background of an individual's life and living' (WHO: 2001, p. 16). They include the *personal* and *environmental* factors that may have an impact on the individual's functioning and ability levels of use, access, and harmony with a designed thing created to empower what meets human needs – table 1.1.

The personal factors represent internal influences on the individual's capabilities/functioning – impacts of the individual's attributes related to *body*, *skill*, *empowerment*, *ideology*, *psychology* and *attitude*. The environmental factors represent the external influences on the individual's capabilities/functioning – impacts of features of the physical, social and attitudinal world (ibid.: p. 11). Inadequate or inferior consideration of the contextual factors, while things are designed, can negatively affect meeting the human needs of individuals, groups or societies. Deconstructing or understanding the *context layer* is fundamental to the design process to characterize the designed thing-individual interactions as a precursor to developing a design solution (Aranda-Jan, C.: 2016, p. 44).

1.5.2.1. The individual – The personal factors:

The human is an integrated context of numerous personal factors whose current features (absence, presence, values and/or qualities) make up his/her corresponding characteristics related to *body*[1], *skill*, *empowerment* and *ideology*[2] which in turn make up his/her psychological and attitudinal characteristics. Personal factors refer to all aspects of the internal world that partly[3] form the context of an individual's life and, as such, have an impact on that person's functioning. In other words, personal factors may act as facilitators or barriers while an individual is interacting in life. Personal factors include age, temporary and permanent impairments, sex, clinal affiliation, abnormality of body measures, nutrition, fitness, knowledge, education, profession, skill level (prior experience), income and wealth, political power, social status[4], geographical location[5], cultural identity (cultural affiliation/adopted culture)[6], and character style[7]. These factors may be classified into body-, skill-, empowerment- and ideology-related personal factors.

1.5.2.2. The interaction environment – The environmental factors:

The environment is an integrated context of numerous environmental factors whose current features (absence, presence, values and/or qualities) make up its corresponding *physical*,

[1] The body-related characteristics are the biological (physical and physiological) characteristics.

[2] Ideology is the intellectual dimension of a group culture or a person's character. It justifies beliefs, values, morals, laws and norms, thus their related customs (customary practices and social behaviours) of such a culture or character. (Facchini, F.: 2011)

[3] The other part is the environmental factors that refer to all aspects of the external world.

[4] Social status, social background or social stratum results in social power, if you view someone as a socially superior, he/she will have power over you because you believe that he/she has a higher status than you do.

[5] From the perspective of an individual's location which is rural or urban, peripheral or central, southern or northern, and eastern or western.

[6] Belonging to a particular group culture means belonging to the collective attitudes of this group based on its inherited and/or recent collective ideologies (ideas and ideals) justifying its beliefs, values, morals, laws and norms, and their related customs (customary practices and social behaviours) regarding the different human living areas. 'These attitudes influence the individual behaviour and social life at all levels, from interpersonal relationships and community associations to political, economic and legal structures' (WHO: 2001, p. 190). A group could be formed on the base of nationality, ethnicity, religion, social class, generation, locality or any kind of social group (e.g. age group) that has its own distinct culture. Culture is a social phenomenon, and the behaviour of a particular individual is shaped by the culture.

[7] Character style or individual attitudes is based on one's ideologies (ideas and ideals) justifying the individual's beliefs, values, morals and norms and their related customs (customary practices and behaviours) regarding the different human living areas. These individual attitudes influence the individual's behaviour at all levels.

social and *attitudinal* characteristics. Environmental factors refer to all aspects of the external or extrinsic world that partly[1] form the context of an individual's life and, as such, have an impact on that person's functioning (ibid.: p. 213). In other words, environmental factors may act as facilitators or barriers while an individual is interacting in life. Environmental factors include the natural physical world, the man-made physical world, support by others, external attitudes and values, and finally services, systems and policies (rules and laws) (ibid.: p. 213, 214). The appendix '*Environmental factors types*' provides more information.

The individual-designed thing relations / **Contextual factors**	**The individual-designed thing relation of Access**	**The individual-designed thing relation of Use**	**The individual-designed thing relation of Harmony**
Personal factors: **related to Body:** age, temporary and permanent impairments, sex, clinal affiliation, abnormality of body measures, nutrition, fitness, knowledge, education, profession[2] **related to Skill:** skill level (prior experience) **related to Empowerment:** income and wealth, political power, social status, geographical location, knowledge, education, profession[3] **related to Ideology:** cultural identity (cultural affiliation/ adopted culture), character style			
Environmental factors: natural physical world man-made physical world support by others external attitudes and values services, systems and policies (rules and laws)			

Table 1.1: The categorized contextual factors affecting the individual-designed thing relations

[1] The other part is the personal factors that refer to all aspects of the internal world.

[2] knowledge, education and profession from the perspective of their effects on the cognitive ability and skill level.

[3] knowledge, education and profession from the perspective of their effects on the person's empowerment.

1.6. Setting the problem – Design exclusion:

Designed things empowering what meets human needs are virtually everywhere, but the problem lies in *unfairness*. While mainstream designed things may be created equal, the ability to access, use and harmonize with them isn't always equal across persons and populations.

'For several years the majority of designers interpreted their social role as complementary to business strategies' (Morelli, N.: 2007, p. 3). Considering this dominant design paradigm known as '*market-driven design*', designs primarily focus on functionality, accessibility (incl. affordability), usability, harmonizability (incl. aesthetics) and viability/profitability; while *equitability* and *environmental quality* are of secondary consideration and often inadequately addressed. In this model, *designed things are economically sustainable, but socially and environmentally unsustainable* because they are functional, accessible, usable, harmonizable and viable only – fig. 1.5.

Regarding *equitability*, the status quo of *social equity in meeting human needs* – mentioned through this research – states that the fundamental human needs are collectively unmet on an acceptable level, and people's dissatisfaction with mainstream designed things is high. This means that their needs aren't included in the scope of design practices or addressed through the design process.

Actually, this is a case of excluding individuals, groups and sometimes societies. They have been vulnerable to *design exclusion*. They are excluded partially or totally from interacting with mainstream designed things – whether through finding difficulties or being unable to *access*, *use* or *harmonize* with such things.

Every decision made during the design cycle can affect design inclusion and people's satisfaction. Failure to correctly understand *the context* can result in a designed thing that unnecessarily excludes people and leaves many more frustrated, leading to downstream problems. (Coleman, R.: 2007, Intro., p. 1-10)

It is worth mentioning that *design exclusion* of individuals, groups or societies isn't necessarily a case of intentional discrimination but it's unquestionably a case of *inequity* and *unfairness*.

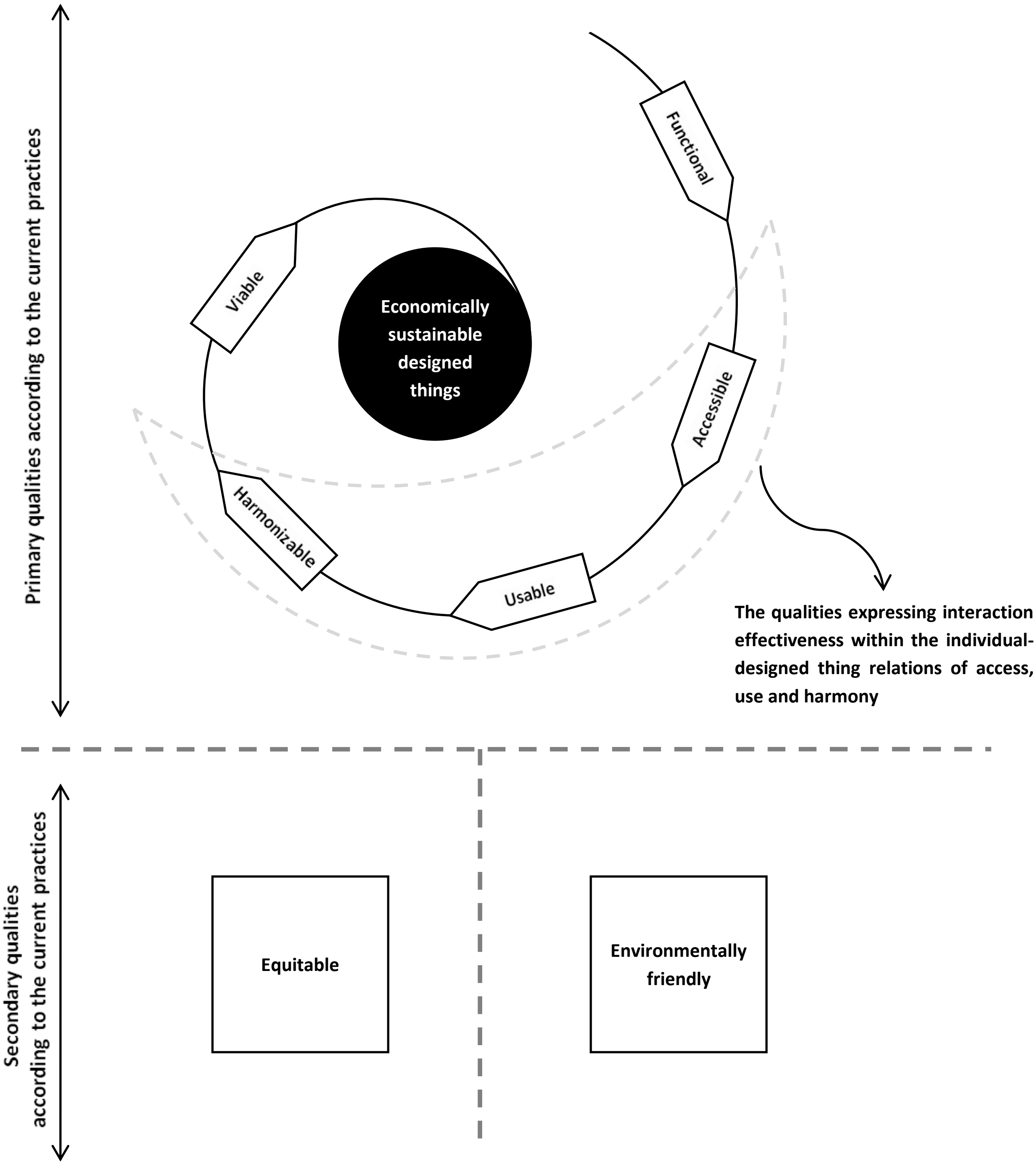


Fig. 1.5: A simple proposed model of the current state of design practices that consider some qualities at the expense of others, which in turn leads to economically sustainable, but socially and environmentally unsustainable designed things.

1.6.1. Changes of roles – Motivators and supporters:

Unfortunately, in the dominant system '*production for the market*', most professional design practices serve via commerce and commercialism (Chick, A.: 2011, p. 70) whose primary purpose of *design for the market* is creating designed things for profit. This has resulted in a major *exchange of roles* between the actors[1] and the served people.

In the optimal system '*production for people*' corresponding with the design definition[2], the people's needs result in the emergence of designed things; here, the people work as motivators, and the actors work as supporters for achieving the people's needs. On the contrary, in the dominant system '*production for the market*', the actors' needs for profits result in the emergence of designed things via expanding human needs to include the *wants* and *desires* of specific groups or societies; here, the actors work as motivators, and the served selected people work as supporters for achieving this target. Those people become the outlet to meet actors' needs, and the other people are easily excluded. This exchange of roles may be acceptable as long as human needs are collectively met on an acceptable level, but with the current *unsustainability* state of the world regarding *social equity*, it requires immediate interventions.

Actually, design is shackled to other goals and values rather than its real ones. In the dominant system, economics and politics of design have been subjected to the whole economic and political current regime. 'Ironically, in an age of hegemonic technology and capitalism, the practice of design has itself become subject to functional direction (pragmatically and symbolically). Increasingly design, as a service, acts on instructions rather than taking action in the original sense' (Fry, T.: 2009, p. 25), or according to its own theory. It lost its free will and its ability to control. Driven by serving the commercial brief, design 'serves an instrumental mode of making that brings things to being without knowing what the consequences will be' (ibid.: p. 26).

[1] Here, actors are members of the design, business and decision-making communities. The design community includes members of design education, design research and design profession; or design students, educators, researchers, amateur designers and professionals. The business community consists of owners, managers, board directors and principal officers down to junior executives. The decision-making community includes members of associations, organizations, agencies, authorities and governments who set rules, regulations, conventions and standards at the local, regional, national and international levels.

[2] 'Design is understood as a means of responding to human need'. (Herling, C.: 2008, p. 267)

1.6.2. A long history of efforts and a continuous dilemma:

Concerns of the design field about the *social responsibility regarding equity in meeting human needs* (the 2nd area of SRD) didn't start here. In various disguises, it has been a recurring theme for many years. According to the conditions, visions and pressing calls for change in the design paradigm, design as a field has committed to addressing *equity* to some degree during its evolution. By the end of the 1950s, designers were encouraged to be more compassionate towards *the underserved*, so several design approaches and requirements have emerged and been developed to avoid *design exclusion* by considering *to some extent* one or more of the spotlighted contextual factors in the design process – e.g. *impairment*, *ageing*, *sex* and *low income*. The following briefly demonstrates some of such contributions adopting *equity* in the design movement.

Triggered by social unrest in the 1950s, the social movement in the US drew attention to *the Physically Handicapped* Americans returning home after the Vietnam War, and approaches such as *barrier-free design*[1] and *design for disability*[2] appeared and took place in the design community (Persson, H.: 2014, p. 507 and Story, M.: 1998, p. 7). In 1963, the British architect Selwyn Goldsmith pioneered the concept of *free access* for people with disabilities (Goldsmith, S.: 1963). In the 1960s, some guidelines on the subject of designing for the *impaired* were published[3]. 'One of the effects of this was the tremendous development of assistive technologies with the purpose of increasing disabled individuals' possibility to participate in everyday life. Examples are most frequent in the area of building and home equipment, such as the one-hand blender, remote controls, and wider doors in trains' (Persson, H.: 2014, p. 507). In 1973, the first *accessibility-focused building code* was adopted in the US; this code was one of the foundations of the later movement to pass federal legislation prohibiting disability discrimination (NCSU Libraries and Wikipedia: Roland Mace).

---

[1] It was introduced to describe the act of creating barrier-free buildings.

[2] At that time, disability was to be expressed through its limited definition: a lack of ability to use a designed thing or complete a task as a result of *defects in the body functions/abilities*, or it can be used interchangeable with the impairment – people with these defects were previously known *people with disabilities*.

[3] For example, in 1961, 'the American National Standard Institute published its first version of ANSI A117.1 – *Making Buildings Accessible to and Usable by the Physically Handicapped*'(Persson, H.: 2014, p. 507); and in 1963, Selwyn Goldsmith published the first comprehensive set of building guidelines on designing for the impaired (Myerson, J.: 2007, p. 23, 24).

In the 1970s and 80s, *feminists* pointed out that *women* without sufficient purchasing power couldn't have their needs met or contribute to design policy (Davey, C.: 2005). They called to increase women's representation within the design profession and their involvement in user -led and resident-led projects (Rothschild, J.: 1999). In Germany and Austria, the integration of women's rights into the practices of local authorities and governments resulted in the design of housing and public spaces that met the needs of women and family-friendly policies (Stummvoll, G.: 2003).

In 1971, Victor Papanek focused the ethical blowtorch on the industrial design profession; he pointed out the designers' responsibilities – implicitly including the *equity in meeting human needs* – in his landmark book *Design for the Real World: Human Ecology and Social Change* (Papanek, V.: 1971). He criticized the design professions, their clients in industry and the associated educational institutions; the core of his argument was that designers focused far too much effort on the aesthetic and stylistic aspects of design rather than considering the whole product – its function, utility, reparability, affordability and its environmental and *social* consequences (Lewis, H.: 2001, p. 19). He called for a change in the design profession and for a new agenda that challenged the dominant *market-led* approach (Papanek, V.: 1971). Regarding *inequity in meeting human needs*, his call gained worldwide popularity and others have responded to it and sought to develop programs of design for *the underserved* ranging from the needs of developing countries to the special needs of the poor, the aged and the impaired (Morelli, N.: 2007, p. 3 and Margolin, V.: 2002, p. 24).

In 1985, Papanek introduced the notion of *design for the third world*, where basic products for people struggling for survival were produced – such as geodesic domes, disaster shelters and muscle-powered vehicles. Also, the notion of *appropriate technologies (AT)* for the developing world was introduced; these technologies aimed to achieve low capital costs, use local labour and materials and create jobs, as well as are controlled by local people and are appropriate to their needs. Furthermore, Papanek introduced the notions of *design for disabled people* and *design for older people*. (Davey, C.: 2005 and Whitelely, N.: 1993)

In conjunction with such notions, he provided lists of products that address *equity*; e.g. teaching aids including aids to transfer knowledge and skills to those with learning difficulties and physical disabilities; training aids for poor people trying to move into the workforce; and equipment and furnishings for mental hospitals. (Margolin, V.: 2002, p. 27, 28)

Unfortunately, Papanek's notions had less impact on the mainstream industrial production, consumer culture, and development policies (Morelli, N.: 2007, p. 3 and Margolin, V.: 2002, p. 24); and many of his suggested products weren't manufactured because a market can't be identified for them (Margolin, V.: 2002, p. 28). Perhaps this can be attributed to his convictions that socially responsible designers must intervene outside the mainstream market (ibid.: p. 27). In this, Papanek pits such designers against the majority of designers who serve markets that practically exclude individuals, groups and sometimes societies. So, such convictions offer very few opportunities to improve the living conditions of *the underserved* (Morelli, N.: 2007, p. 3).

In 1989, the Center for Accessible Housing in North Carolina was founded with a mission to improve the quality and availability of housing for *people with disabilities*, including ones that result from *ageing*.[1]

In 1991, the DesignAge action research programme was established at the Royal College of Art (RCA) to explore the design effects of *ageing* populations. The team managed to make the ageing a hot topic for young designers. DesignAge also established a European network called Design for Ageing Network (DAN) to pursue the agenda. (Myerson, J.: 2007, p. 26)

At the beginning of the 1990s, the concept of *transgenerational design* was developed to describe designed things that meet the needs of people across a wide range of ages; also a series of guidelines and strategies for applying this concept was evolved (ibid.: p. 29). Such a concept 'is framed as a *market-aware response* to population ageing and the need for products and environments that can be used by both young and old people living and, importantly, working in the same environment'. (ibid.: p. 29)

In 1994, Archeworks – a private educational institution in Chicago – launched the one-year certificate program that is dedicated to advancing a socially responsible design agenda. Each year, it introduces a small interdisciplinary group of students with varied intellectual back-grounds to a process of social design that has resulted in some projects and studies including a device for people with Alzheimer's disease to facilitate their getting into an auto-mobile, and a head-pointer designed for people with cerebral palsy. In most cases, projects have been conducted in collaboration with social service organizations or agencies, and many have been funded by grants from public and private sources. (Margolin, V.: 2002, p. 29)

[1] nchpad.org/Directories/Organizations/2558/Center~for~Universal~Design~-~North~Carolina~State~University

Broader approaches: At the end of the 20th century, the notion of *inclusivity* attracted a great deal of design interest and activity, and huge momentum happened in the field of design; the previous efforts began to give way to more *egalitarian* concepts, which have been offered to consider more than one factor of the contextual factors. *Universal design (UD)*, *design for all (DfA)* and *inclusive design* approaches appeared and took place in the design community. They largely focus on increasing *coverage* of the designed things for the widest possible range of people. Such approaches come from diverse origins but over time have been converging to the common goal of *inclusiveness*. They have been developed over the last 2 decades and can be seen as adopting the vision not limited to discussions on *defects in the body functions/abilities* or considering not only one factor of the contextual factors but also *the variety of the contextual factors*. They put a high value on *diversity*, but to what extent have they deeply considered it?

Unfortunately, such approaches haven't been developed enough to be *sensitive to the whole context* (the wide space of the contextual factors) *and its dynamic diversity*. Although they resulted in an effective space of change, they have some shortcomings on the level of *concept, details*, *application, realm* or *practicality* which show that we are still far away from deeply understanding *the variety of contextual factors and their dynamism*. For example, the UD definition, principles and guidelines concentrate only on *equal usability* at the expense of *equal accessibility* and *harmonizability*. Also, most of its guidelines comprehensively consider *impairment* and *aging* at the expense of the other contextual factors. On the *applied* level, its aim has become as if it was to ensure that no one should be excluded only because of their functional difficulties. On the *realm* level, UD has its origins and activities in industrial and architectural design, and targets products and built environments, *not* the whole realm of designed things (products, services, systems, environments and technologies). Additionally, UD overlooks the *practicality* (Vanderheiden, G.: 2009, p. 3- 13) by depending on a single solution that works for everyone without setting *practical limits*; but what is possible isn't necessarily commercially viable. For more clarification, see section 2.12.2.

A continuous dilemma: Although all of the previous concepts and approaches, there has been little theorizing about *equity in design*, and little thought has been given to the structures and methods of it. Also, regarding the broader understanding of how *equitable design* might be commissioned, supported and implemented, little has been accomplished. Such concepts and approaches *haven't been promoted* enough within the design, business and decision-making communities. Although ethics and social responsibility are currently high on the international agenda and have been recognized by the 3 communities, the *equity* of the artifactual world we create, use and occupy has been hardly observed.

Within the *design community*, there's a general lack of awareness of many issues relating to *social sustainability* issues which are currently rarely addressed in the design brief and as such it's often difficult for designers to have the opportunity to engage with socially sustainable design in a professional capacity (Bhamra, T.: 2007, p. 4, 5). Nor has attention been given to changes in the education of designers that might prepare them to consider *the underserved* rather than the market alone (Margolin, V.: 2002, p. 24). As far as we are aware, no university programmes work on preparing *integral designers* who may consider *social sustainability* while commercially serving.

Regarding the *business community*, many companies have established their *corporate social responsibility (CSR)* agendas – voluntarily or forced by legislation, rules and regulations. They contribute to economic development while improving the quality of life of the workforce, their families, and to some degree the local community and society (by reducing their environmental impact) (Bhamra, T.: 2007, p. Xvi). Regarding *equity in meeting human needs* (the 2nd area of SRD), business concerns have been insignificant. Conditions of *social inequity in meeting human needs* (*people exclusion*) around the world inform that the logic of economic rationalism seemed unbreakable, and it didn't contribute to any exploration of the middle ground between pure market-based industrial logic and *equitable design* (Morelli, N.: 2007, p.3).

Actually, the previous efforts have *to some degree* broadened the design requirements to help get a socially sustainably designed thing, but unfortunately they collectively have minimal effect; because if they were effective, why has the world existed in such a state of unsustainability regarding social *equity in meeting human needs* (the 2nd area of SRD), or why have individuals, groups and societies still been experiencing *design exclusion*? The incomplete picture of the *equitable design* issue and its little reinforcement within the design, business and decision-making communities have easily made the efforts of limited effects. In turn, the *dilemma of design exclusion* has been continuous.

Efforts are insignificant without a deep understanding of the dynamic diversity of people's contexts, parallel applicable approaches and conscious adoption of such approaches by the design, business and decision-making communities.

Our *challenge* is, first, to fully set the breadth of the agenda (the whole picture) to help reach a more advanced and holistic approach which should be comprehensively sensitive to the dynamic diversity of people's contexts; second, to find ways to promote this approach within the design, business and decision-making communities. This may change the current situation, help break the barriers or reduce the distance between market-based systems and socially oriented initiatives, and encourage a more widespread approach to *equitable design*. Hopefully, this study brings us a little closer to a more *socially sustainable vision* for improving the quality of life for all people.

1.7. Research problem, questions, hypotheses, objectives and limits:

Research problem:

This study examines the phenomenon '*the correlation between design and the unsustainability state of the world*' specifically '*social inequity in meeting human needs*'. It seeks to discover deficiencies in the past and current design practices behind this state, and put forward suitable elaborative approaches accordingly to avoid the recurrence of this phenomenon.

This study is concerned with the *social side of sustainability* at the expense of the environmental and economical side.

Research questions:

- What are the causes related to design practices that make design correlates with the *unsustainability state of the world* regarding the *social inequity in meeting human needs*? Or what don't design practices consider and contribute to the *unsustainability state of the world* regarding *social inequity in meeting human needs*?
- How does the recognition of the causes behind this phenomenon contribute to tackling it? The proposed cause related to design practices behind this phenomenon is a cause related to how effective design practices are in equally actualizing the noble social role of design – in meeting fundamental human needs on a global scale.

Research hypotheses:

- Not deeply considering the *dynamic diversity of people's contexts characteristics* in design practices or *unequal design practices* is a main cause of the correlation between design and the *unsustainability state of the world* regarding the *social inequity in meeting human needs*.
- Past and current design practices serving under the dominant systems haven't considered the different levels of people's ability of accessing, using and harmonizing with designed things, which in turn has collectively created an unequal state in meeting human needs across people, hasn't collectively provided what empower what fully and consistently meet people's needs on an acceptable level, or hasn't collectively actualized the noble social role of design on an acceptable level.
- Validating the above 2 proposed hypotheses could facilitate structuring and establishing new *projective knowledge* that would be inherently more socially sustainable. This knowledge may be of value and applicably useful in helping avoid the phenomenon and solving urgent problems; and will hopefully raise the awareness needed to promote its message within the *design*, *business* and *decision-making communities* – i.e. to change the mindsets of all actors, which in turn may pave the way for shaping humans' future in a socially sustainable fashion.

Research objectives:

- Challenging our understanding of design practices consequences, and reframing our conceptions of designed things.
- Providing a solid socio-theoretical substructure for the *design theory* to regain social relevance, via addressing social considerations, identifying the weaknesses and failures of design in this context, acknowledging concrete concepts and ideas (verified and generalized *theoretical knowledge*), and establishing *projective knowledge* being inherently more socially sustainable. The projective knowledge may hopefully be of value and applicably useful to guide the new design practices to address the *agenda of sustainability* regarding *social equity in meeting human needs* (*equity within generations*) and pave the way for shaping humans' future in a socially sustainable fashion. Then bringing these new practices to tackle the complex and pressing problems of a world made socially unsustainable.

- Reinforcing the educational curriculums of design to help *design students* – forming the foundation of the future design community – know how to achieve *social sustainability* regarding *equity in meeting human needs* by depending on, first, the verified and generalized knowledge of the theoretical parts represented in the full reality of individual-designed thing relations, the dynamic diversity of people's contexts, the socially unsustainable results of our current design paradigm (*design exclusion*), and the verified causes behind this exclusion; second, the structured and established knowledge of the projective parts that would be inherently more socially sustainable, and clarify the good power of design.
- Contributing to raising awareness of the *design*, *business* and *decision-making communities* regarding deficiencies in design practices behind the *social unsustainability state of the world*, and how to avoid recurrence of them, for rectifying their conceptions about the quality of *design practices*, *economics* and *politics*.
- Sharing in restoring the world to a state of *sustainability* for the current and next generations.

Research limits:

Considering that this study is concerned with the *social* side of sustainability, only *design exclusion* resulting from *unequal usability* and *unequal accessibility* will form the overall study content. For *design exclusion* resulting from *unequal harmonizability*, it may be a prospective study – fig. 1.6.

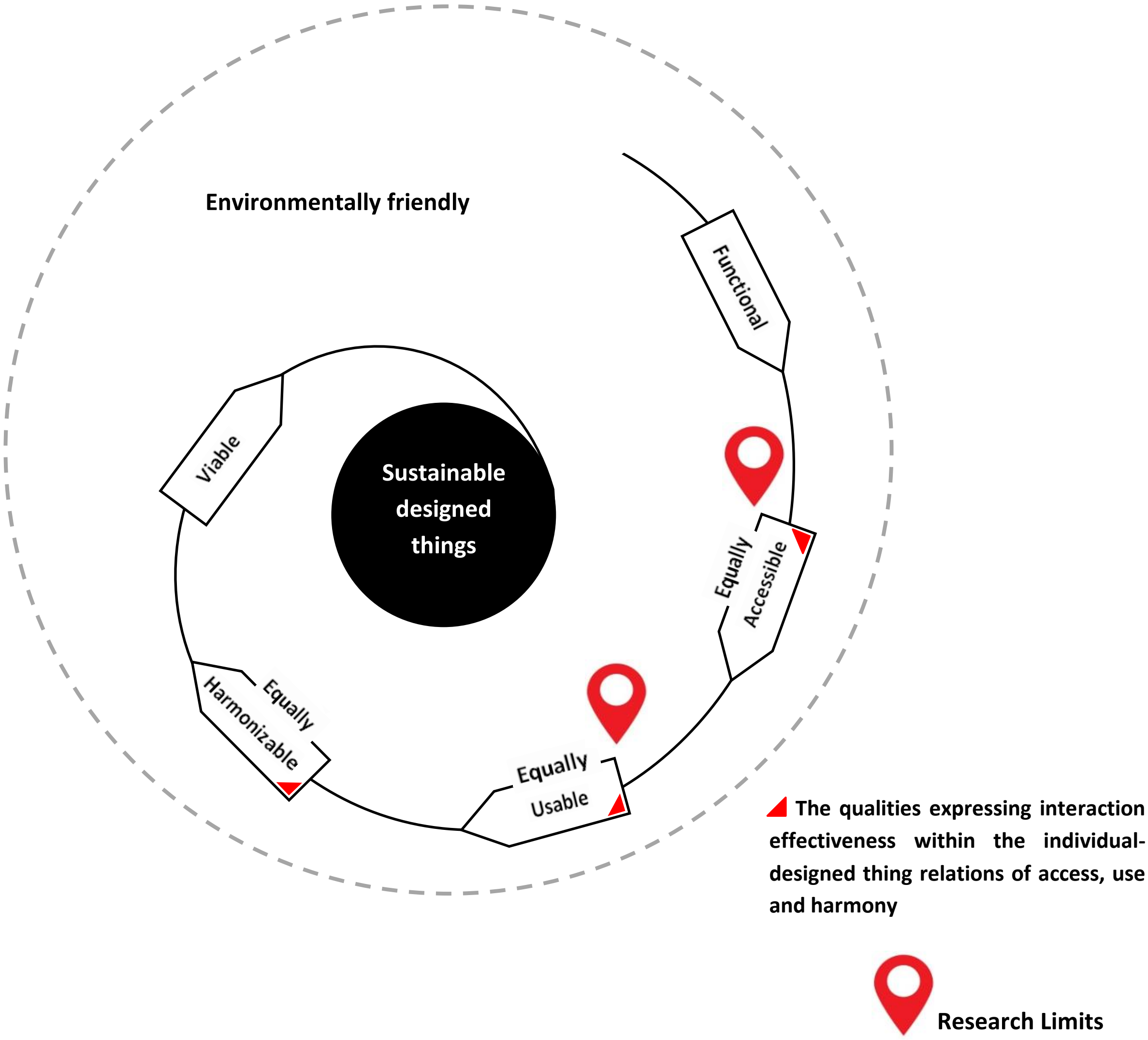


Fig. 1.6: Research limits – mapping the selected parts of the optimal model of sustainable design that will be studied.

1.8. Research workflow:

To examine and tackle the phenomenon under study, answer the research questions and validate its hypotheses – considering the research limits, the study approaches a *theoretical* and a *projective* path:

- **The theoretical path:** To examine the first 2 proposed hypotheses, *design exclusion* will be analyzed according to the *individual-designed thing relations of use and access*. Here, we aren't going to discuss if *usability* and *accessibility* haven't been considered while designing things or not. They are 2 of the main considerations, and couldn't be ignored in the entire design process. Here, the study is concerned with how *profound* and *equitable* are usability and accessibility considered while designing things? Aiming to optimize usability and accessibility for the largest number of people and populations, the debate is concerned with concluding, first, what isn't recognized or considered while design is practiced, and negatively affects the quality of usability and accessibility; second, what isn't recognized or considered, and makes the usability and accessibility level of a designed thing low or nonexistent for some, or not equal among people or populations.

- **The projective path:** Validating the first 2 proposed hypotheses may facilitate structuring and establishing new *projective knowledge* – new suitable elaborative design approaches – for supporting the optimal model of sustainable design. In such approaches, *equitability* would be of *primary consideration* and adequately addressed. It's logical to generally suggest the *equitable design* approach, and closely, the *design for equal usability* and *design for equal accessibility* approaches. Both approaches and their details (answering *what* should be done or changed, and *how*) may be of value and applicably useful in helping avoid design exclusion; tackle the pressing and complex issues of a world made socially unsustainable; and ensure that all people find what is useable and accessible for participating in daily life activities, achieving tasks and satisfying their human needs. In this, and considering the postponed approach '*design for equal harmonizability*', design can address the *agenda of sustainability* regarding *social equity in meeting human needs* – *equity within generations* – and pave the way for shaping humans' future in a socially sustainable fashion.

Table 1.2 shows the areas through which the study flows from the *theoretical* path to the *projective* one.

Design exclusion and Usability	Design exclusion and Accessibility	Design exclusion and Harmonizability

The individual-designed thing relations / Contextual factors	The individual-designed thing relation of Use	The individual-designed thing relation of Access	The individual-designed thing relation of Harmony
Personal factors: **related to Body:** age, temporary and permanent impairments, sex, clinal affiliation, abnormality of body measures, nutrition, fitness, knowledge, education, profession **related to Skill:** skill level (prior experience) **related to Empowerment:** income and wealth, political power, social status, geographical location, knowledge, education, profession **related to Ideology:** cultural identity (cultural affiliation/ adopted culture), character style			
Environmental factors: natural physical world man-made physical world support by others external attitudes and values services, systems and policies (rules and laws)			

Theoretical study

Design for equal Usability	Design for equal Accessibility	Design for equal Harmonizability
Equitable Design		

Projective study

Table 1.2: The research flows across the gray areas.

1.9. Thesis outline:

In addition to the parts: introduction, discussion, references, appendices and appendices references; this thesis consists of 2 main parts. Each part consists of a set of sections flowing from *theoretical* to *projective* work.

1. **Introduction**
2. **Design exclusion and usability**

2.1. Introduction 2.2. The use relation 2.3. Anatomy of the use relation 2.4. Human body systems and body abilities 2.5. The User – The personal factors 2.6. The performance environment – The environmental factors 2.7. What should actors and design practices consider? 2.8. Design exclusion regarding usability 2.9. Is there an urgent need to change?	Theoretical study
2.10. 'Design for equal usability' as a part of 'equitable design' 2.11. How to promote 'design for equal usability'? 2.12. The origin and advancement of 'design for equal usability'	Projective study

3. **Design exclusion and accessibility**

3.1. Introduction 3.2. The access relation 3.3. Contextual factors related to the access relation 3.4. What should actors and design practices consider? 3.5. Design exclusion regarding accessibility 3.6. Answering the questions	Theoretical study
3.7. 'Design for equal accessibility' as a part of 'equitable design' 3.8. How to promote 'design for equal accessibility'?	Projective study

4. **Discussion**
5. **References**
6. **Appendices**
7. **Appendices references**

1.10. Research methodology:

According to the applied *procedural method*, this study follows the *descriptive*, *causal* and *projective normative* studies. This study is working to get an accurate description of the phenomenon '*the correlation between design and the unsustainability state of the world*' specifically '*social inequity in meeting human needs*' by collecting and analyzing data that accurately describes the phenomenon and its status quo via answering *what* this phenomenon is; and to discover underlying causes related to *design practices* behind this state for achieving a more comprehensive and deeper understanding of this phenomenon via answering *how* and *why* this phenomenon has occurred. Besides, the study is also working to set up *what* should be done or changed and *how* in light of the information derived from the phenomenon description and recognition of causes behind it.

In this regard, the study tries first to describe the phenomenon and discover causes behind it to add new verified and generalized *theoretical knowledge* to the body of knowledge; and second to use this in setting up new *projective knowledge* (new suitable elaborative approaches) which could be followed for avoiding recurrence of this phenomenon. In other words, the study first describes, analyzes and interprets this phenomenon – *evaluates* the phenomenon; and second *projects* its future and tries to control and adjust it.

Thus, this study can be classified according to its *nature* and *underlying motivation* (purpose of study) as a *theoretical* and *projective* study.

- The theoretical side of this study is concerned with evaluating the phenomenon which may produce new verified and generalized *theoretical knowledge*. It may be of value and may contribute to the growth of scientific knowledge and thus achieve a more comprehensive and deeper understanding of the phenomenon.
- The projective side of this study is concerned with setting up new *projective knowledge* (new suitable elaborative approaches) based on the new verified and generalized theoretical knowledge. This new projective knowledge may be of value and applicably useful in helping avoid design exclusion, and tackle the pressing and complex problems of a world made socially unsustainable. Also, it may contribute to the growth of scientific knowledge, which in turn guides the new design practices to address the *agenda of sustainability* regarding *social*

equity in meeting human needs – equity within generations – and pave the way for shaping humans' future in a socially sustainable fashion.

Together, the *theoretical* and *projective knowledge* may provide effective knowledge that may be of value in refining the *design theory* and growing the scientific knowledge, and enable us to think about design in new ways and guide the new design practices to produce *socially sustainable design*.

Research tools – Means for collecting data: For answering study questions and testing its proposed hypotheses, this study relies on the *indirect observation* tool in collecting data through contacting specialized books and journals, certified and dependable statistics and reports, and other materials related to the study structure. It's a quantitative and qualitative survey of the published and printed materials – a literature survey. The nature, hypotheses and aims of the study are the reasons for choosing this tool for collecting data. Thus, the study can be classified according to *how data is collected* as an *observation study*.

Methods of processing data: According to the nature of the research problem and the collected and extracted data, processing the data will depend on the *qualitative analysis* method for analyzing and processing data. The collected data will be qualitatively analyzed and explained to extract the scientific proofs (*what*, *how* and *why* this phenomenon), which answer the 1st research question and confirm or reject its proposed hypotheses. The extracted data will be qualitatively analyzed and explained for setting up new *projective knowledge* (*what* should be done or changed, and *how*). This requires more mental effort. *Induction*, *deduction* and *abduction* will be the followed reasoning processes for analyzing and processing the collected and extracted data in this study.

For the theoretical path, *inductive* and *deductive reasoning* are the processes that will be followed. For the projective path, *abductive reasoning* is the process that will be followed. This sequence of the reasoning processes is an attempt to identify prescriptive/normative statements (*what ought to be*) based on descriptive/positivist statements (*about what is*); i.e. to set up *projective knowledge* based on verified and generalized *theoretical knowledge*. Thus, this study can be classified according to the followed forms of thinking as an *inductive*, *deductive* and *abductive study*.

2. Design exclusion and usability

2. Design exclusion and usability

2.1. Introduction:

With having the ability to access and harmonize with a designed thing, some people and sometimes people's segments find difficulty in using it or are unable to use it, although it's used for its predetermined or mainstream purposes[1]. And as a consequence, their needs – sometimes their basic needs – may not be met. This means that their needs haven't been included in the scope of design practices or addressed through the design process. In other words, these people were vulnerable to design exclusion regarding usability.

At a glance[2], frequent scenes in our everyday life could clearly demonstrate this. No one wasn't asked by an old adult to help open a tightly closed water bottle or a jar of jam, move a heavy chair from place to place, or set up his/her new digital television or mobile phone. In many developing countries, we could observe wheelchair users who suffer to get up or down the stupidly elevated sidewalks being without kerb cuts. Many women ask men for help in tasks requiring the usage of hammers or boring machines because using them requires body ability levels exceeding their own. We can also observe obese children in the playground being unable to use the toboggan due to its standardized width which doesn't fit their size; tall persons in the cinema or the plane seeming annoyed because they can't sit comfortably due to the standardized distance between their seats and the back of the front seat not spacious enough to accommodate their long legs; and adults in front of automated ticket machines who can't recognize how to use them because they are used to buy tickets from ticket offices. Finally, we always find difficulty in watching the TV screen being near a window on a sunny afternoon.

Thinking about this, the previous people have been excluded partially or totally from the mainstream of using the above-mentioned designed things. Actually, everyone may be

[1] Some designed things may be used for purposes that aren't predetermined (Coleman, R.: 2007, Inclusive design process, p. 2-26).

[2] Adequately explained examples are shown in section 2.8.

vulnerable to finding difficulties in using some designed things or be unable to use them, and may be annoyed and sometimes obliged to wear an apologetic smile while asking for help.

Easy-to-use (easily usable) designed things are pleasurable and satisfying to use, while those that are *difficult-to-use* will cause frustration for many people and exclude some altogether (Coleman, R.: 2007, Intro., p. 1-12). The emotions coinciding with using a designed thing could be classified as *use-induced emotions*[1] which in turn affect the *use-induced acceptability*[2] and *desirability* of the user toward this thing. Frustration with, or inability to use a designed thing can lead to a negative brand image; at the extreme, prolonged difficulties with poorly designed everyday things can even convince people that they are no longer able to lead an independent life (ibid.).

Now, the question is *why are the aforementioned people exposed to these situations?* And *what does this mean?* Considering that the aforementioned designed things aren't directed to a specific group over others; simply, the reason is that these things placed high use demands on their aforementioned users; profoundly, the reason is that some matters related to the use relation haven't been considered throughout the entire design process; thus, a satisfactory level of usability isn't achieved for all people of the target group.

Usability (the ability of use) is the extent to which a designed thing can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified performance environment (ISO 9241-11: 1998). It refers to the functional relationships between people and the designed things they use (Bremner, C.: 2008, p. 425). A usable designed thing for an individual means that he/she can physically interact with it easily, or that use-related characteristics of his/her context are considered.

Actually, while a designed thing may be *equally* created to be *easily usable*, using it comfortably isn't always equal for all individuals. Some find difficulty in using it or are unable to use it. In turn, this thing may not be able to fulfill its purported function for these individuals. Here, we aren't going to discuss if *usability* hasn't been considered while designing things or not. It's a main consideration and couldn't be ignored in the entire design process. A handheld

[1] Use-induced emotions are those induced by the effectiveness and efficiency of use.

[2] Use-induced acceptability forms with access- and harmony-induced acceptability the whole acceptability and the whole desirability toward a designed thing.

computing tool should have a large enough screen to allow people to view information comfortably; when screens are too small, the user may become vision-impaired in this particular situation (Ashok, M.: 2009, p. 4-4). Also, it shouldn't be so large that it leads to increased weight, thus making it less portable (ibid.).

Here, the study is concerned with how *profound* and *equitable* is *usability* considered while designing things? Aiming to optimize usability for the largest number of end-users, the following debate is concerned with concluding, first, what isn't recognized and considered while design is practiced and negatively affects the quality of *usability*; and second, what isn't recognized and considered and makes the usability level of a designed thing low or nonexistent for some, or not equal among all end-users[1]. This requires detailed anatomy of the *user-designed thing relation of use* through which it could be determined what should be recognized and considered for reaching a high level of usability and ensuring it for a high percentage of end-users for a long time. The following shows the required detailed *anatomy of the use relation*.

2.2. The use relation:

Regarding our point, *the current state of a user's ability of using a particular designed thing* is a result of the interaction between *the current state of his/her body abilities related to using it* and *the current demands of using it*; i.e. between the state of the user's body abilities related to using this thing and the demands of using this designed thing within a particular environment and in a specific moment. The first is derived from *the user's current biological (anatomical and physiological) characteristics* related to using this thing, and the second is derived from *the current physical and behavioural characteristics of the designed thing* or the current use-related characteristics of the designed thing which are made up from the features of some factors such as size, colour, quality, shape, weight, usage method (inter-action sequence) and so on – fig. 2.1.

[1] The following debate is concerned with to what extent 2 main matters are actually well recognized and considered throughout the entire design process of a designed thing. The 1st matter is the pillars and aspects of the use relation controlling the *quality of usability*. The 2nd matter is the diverse and dynamic contexts of use (*diversity* and *dynamism* of who uses and where this thing is used) resulting in diverse values of these pillars and aspects, and controlling the *quality of coverage* (the number of end-users who experience a satisfactory level of usability while using this thing) and the *quality of continuity* with a satisfactory level of usability.

Ease of use for a user arises when the current demands of using a particular designed thing fall behind or at least are equal to the current state of related body abilities of this user. Difficulty or inability of use (both express *design exclusion*) arises when the current demands of using a particular designed thing exceed the current state of related body abilities of this user. At worst this difficulty leads to the user being unable to use the designed thing; at best the designed thing may be difficult or frustrating to use. (Clarkson, J.: 2007, p. 165, 166)

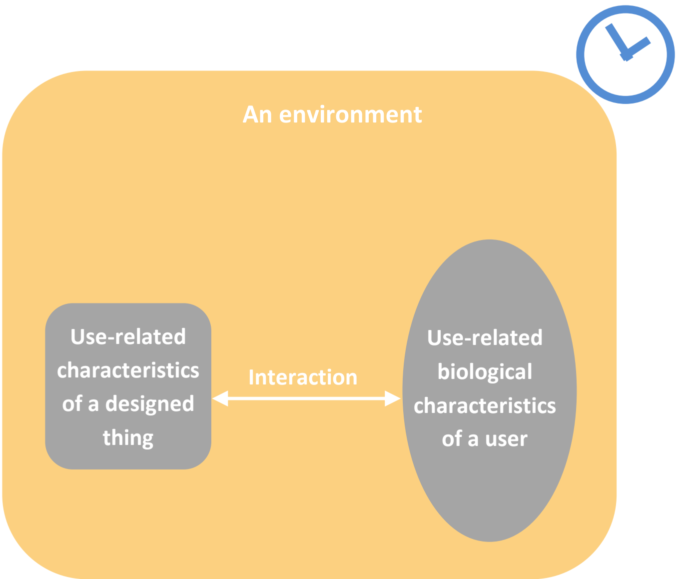


Fig. 2.1: A simple model of the use interaction between a user and a designed thing.

According to this interaction relation of use, the ability state of using a designed thing ranges from full functioning to full disability[1] during use (from finding ease, to having a little difficulty, to having more difficulty, to being unable to use the designed thing). While the functioning of using a designed thing is an umbrella term for the positive aspects of the interaction, the disability of using a designed thing is an umbrella term for the negative aspects.

[1] Disability related to use is the lack of ability to complete a task as would have normally been expected.

2.3. Anatomy of the use relation[1]:

From the above, and depending on the concluded data of sections 2.5 and 2.6, *in a specific moment*, 2 main pillars are controlling the use relation or the current level of the user's ability of using a designed thing.

The 1st pillar is *the current state of the user's body abilities related to using the designed thing* and it reflects 2 aspects:

- *The own biological state of the user's body systems related to using the designed thing*. It's concerned with to what extent his/her related body systems function well. It's based on the physical/anatomical and physiological measures of these systems and reflects the effects of some personal factors on these systems. *Aspect Nr. 1*
- *The circumstantial biological state of the user's body systems related to using the designed thing*. It's concerned with the biological state of the user's body systems related to using the designed thing in the context of use. It reflects 2 aspects:

- *The performance environment-induced biological state of the user's body systems related to using the designed thing*. It's concerned with to what extent his/her related body systems function well in the performance environment. It's based on the physical and physiological measures of these systems in the performance environment and reflects the effects of some environmental factors on the own biological state of these systems. *Aspect Nr. 2*
- *The assisting aids-induced biological state of the user's body systems related to using the designed thing*. It's concerned with temporary and permanent changes that may occur in the own biological state of the user's body systems related to using the designed thing by the user as a form of *adaptation* to the personal or environmental factors directly related to the use relation through depending on assisting aids (incl. medical devices[2]). It's based on the physical and physiological measures of these systems in the existence of assisting aids and reflects their positive effects on these systems. *Aspect Nr. 3*

The 2nd pillar is the *current demands of using the designed thing* and reflects 2 aspects:

[1] The anatomy of the use relation is based on sections 2.5 and 2.6.

[2] – such as mobility aids (e.g. walking aids, seated walking scooters, wheelchairs and stairlifts), hearing aids (body worn, behind the ear and in the ear aids) and seeing aids (e.g. eyeglasses and corrective contact lenses).

- *The original/by design state of use-related characteristics of the designed thing* (incl. the method of use). It's concerned with the use-related characteristics created to achieve the intention of the design project. The *Critical Aspect*
- *The circumstantial state of use-related characteristics of the designed thing*. It's concerned with the state of its original characteristics in the context of use. It reflects 2 aspects:

- *The performance environment-induced state of the designed thing characteristics related to use*. It's concerned with the state of its original characteristics related to use in the performance environment. It's concerned with temporary or permanent changes that may occur in these characteristics due to the effects of some environmental factors. *Aspect Nr. 4*
- *The user-induced state of the designed thing characteristics related to use*. It's concerned with temporary and permanent changes that may occur in its original characteristics related to use by the user as a *reaction* to the personal or environmental factors directly or indirectly related to the use relation, or in line with the user's intentions of using it. By exerting their will, people use the manufactured world to suit their contexts and intentions of use. People may not be maintaining its original characteristics related to use as designed and may not be using it as designed (for its predetermined purposes). Such changes reflect both the adaptation of the user and the intention of the user's project. *Aspect Nr.5*

There's another pillar that controls the current level of the user's ability of using the designed thing, this is *the user's decisions toward using the designed thing*. These decisions are materialized through the user's actions regarding *participation* and *adaptation* which form his/her *engagement state* in using this thing. *Participation* affects the occurrence and activation of the use interaction, and with the recurrence of participation, it affects the buildup of the user's experience of using this thing, which in turn affects his/her ability of using it. *Adaptation* through modifying one or more aspects of the 2 main pillars of the use relation affects the quality of use interaction; adaptation aims to improve the ease of using, accessing or harmonizing with the designed thing. Such decisions reflect the user's current psychological state toward (reflect how the user perceives): all matters related to the user -designed thing relation of use, such as the 1st, 2nd, 4th and critical aspect of the interacting pillars, the interaction competence between them, and others; and all matters related to the user-designed thing relation of access and harmony, such as the aspects of both relations, the interaction competence of both relations, and others.

In regards to the use relation, the user's decisions based on how to perceive some aspects of the use relation (aspects Nr. 1, 2, 4), and their potential effects on interaction competence (efficiency of use) are actually reactions to the effects of some personal and environmental factors in forming these aspects. In addition, the user's decisions based on how to perceive some other matters related to these effects are consequently other reactions to the effects of the same personal and environmental factors.

Similarly, in regards to the access and harmony relations, the user's decisions based on how to perceive some aspects of both relations and their potential effects on interaction competence (efficiency of access or harmony) are actually reactions to the effects of some personal and environmental factors in forming these aspects. Additionally, the user's decisions based on how to perceive some other matters related to these effects are consequently other reactions to the effects of the same personal and environmental factors – e.g. see sections 3.2 and 3.3 regarding the access relation.

Thus, the 3rd pillar *'the user's decisions toward using the designed thing'* reflects 4 aspects:

- The user's decisions induced by personal factors *directly* related to the use relation due to their effects on the use relation[1] or due to other matters related to these effects or being considered by the user. *Aspect Nr. 6*
- The user's decisions induced by environmental factors *directly* related to the use relation due to their effects on the use relation[2] or due to other matters related to these effects or being considered by the user. *Aspect Nr. 7*
- The user's decisions induced by personal factors directly related to the access or harmony relations (*indirectly* related to the use relation) due to their effects on these relations or due to other matters related to these effects or being considered by the user. *Aspect Nr. 8*
- The user's decisions induced by environmental factors directly related to the access or harmony relations (*indirectly* related to the use relation) due to their effects on these relations or due to other matters related to these effects or being considered by the user. *Aspect Nr. 9*

Fig. 2.2 explains the previous analysis and shows the 3 main pillars and their aspects.

[1] – through their role in forming *the aspect Nr. 1* of the use relation, thus in interaction competence of it.

[2] – through their role in forming *the aspects Nr. 2 & 4* of the use relation, thus in interaction competence of it.

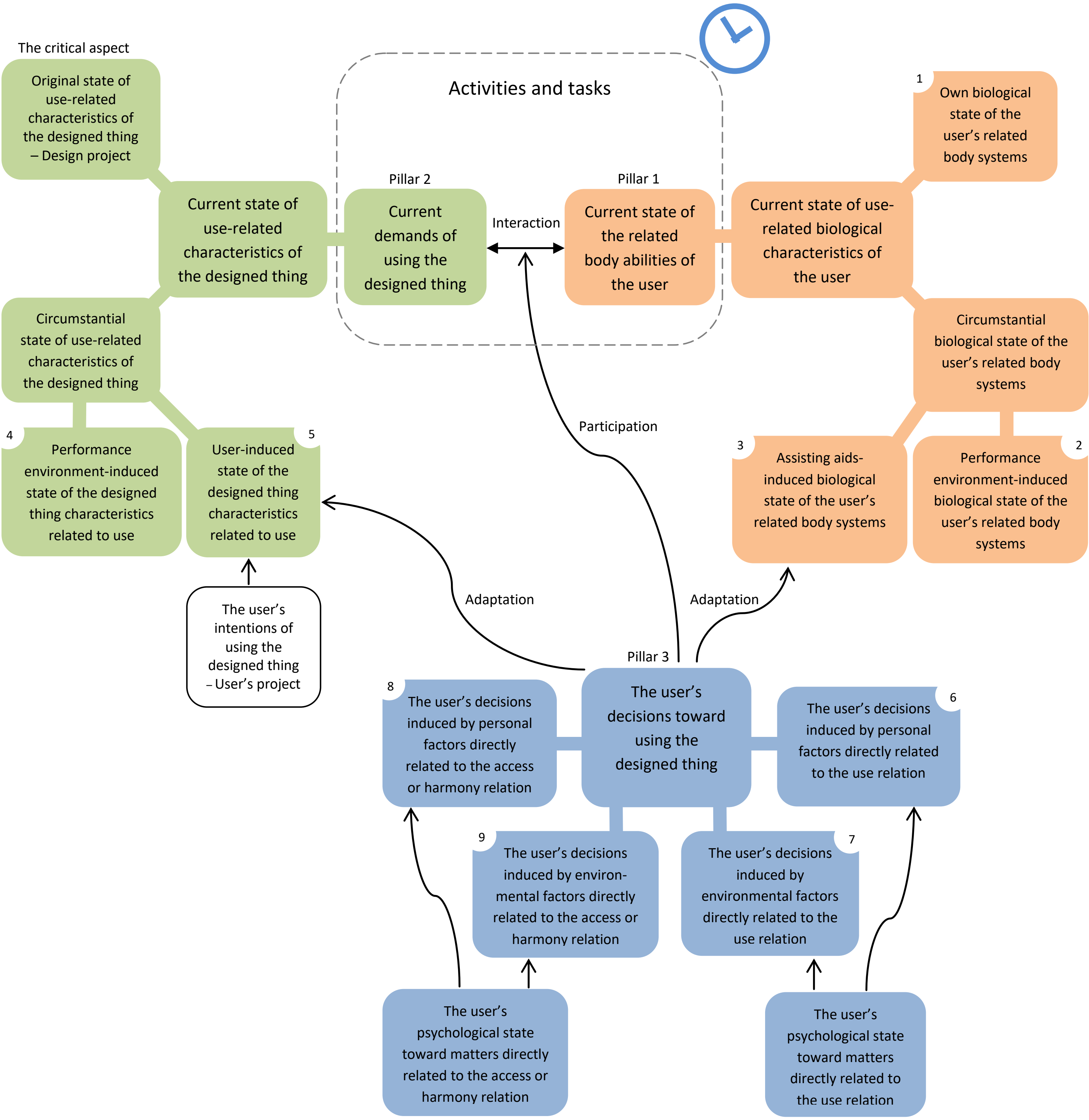


Fig. 2.2: An anatomic scheme of the use relation shows its 3 main pillars and their aspects.

Looking deeper, *in a specific moment* and with using a designed thing for its *predetermined* or *mainstream purposes*, the current state of a user's ability of using is a reflection of to what extent *the 9 aforementioned aspects* are taken into account while *the original use -related characteristics of this thing* (*the critical aspect controlled by design practices*) are created.

A more organized model of the previous scheme shows *the 9 aspects* on the right side facing *the critical aspect* '*original use-related characteristics of the designed thing*' on the left side – fig. 2.3. To ensure that the current demands of using a particular designed thing don't exceed the current state of related body abilities of a user and thus ensure for him/her an adequate level of ease of using this thing, requires considering *the 9 aspects*. Difficulty or inability of use (both express *design exclusion*) for the end-users arises when the original characteristics of the designed thing are created without considering *the 9 aspects* of those users.

Looking deeper and deeper, *in a specific moment* and with using a designed thing for its *pre-determined purposes*, the current state of a user's ability of using a designed thing is a reflection of to what extent the impacts of this user's contextual factors (personal and environmental factors) on *3 main concepts* – impacts making up the 9 aspects – are considered when *the original use-related characteristics of this thing* are created. *The 3 concepts* are:

- *the user's body abilities related to using the designed thing* (the 1st concept),
- *the designed thing characteristics related to use* (the 2nd concept), and
- *the user's decisions toward using the designed thing* (the 3rd concept) – table 2.1.

To avoid *design exclusion* for a targeted user or to ensure that the current demands of using a particular designed thing don't exceed his/her current state of related body abilities, requires considering the impacts of this user's contextual factors on the 3 concepts; in turn, requires full awareness of the 3 concepts, the contextual factors, and how they affect the 3 concepts and thus affect the current level of a user's ability of using a designed thing. The following sections are an extensive clarification in regards to:

- Section 2.4: The human body abilities
- Section 2.5: The personal factors and their effects on the user's ability of using a designed thing
- Section 2.6: The environmental factors and their effects on the user's ability of using a designed thing

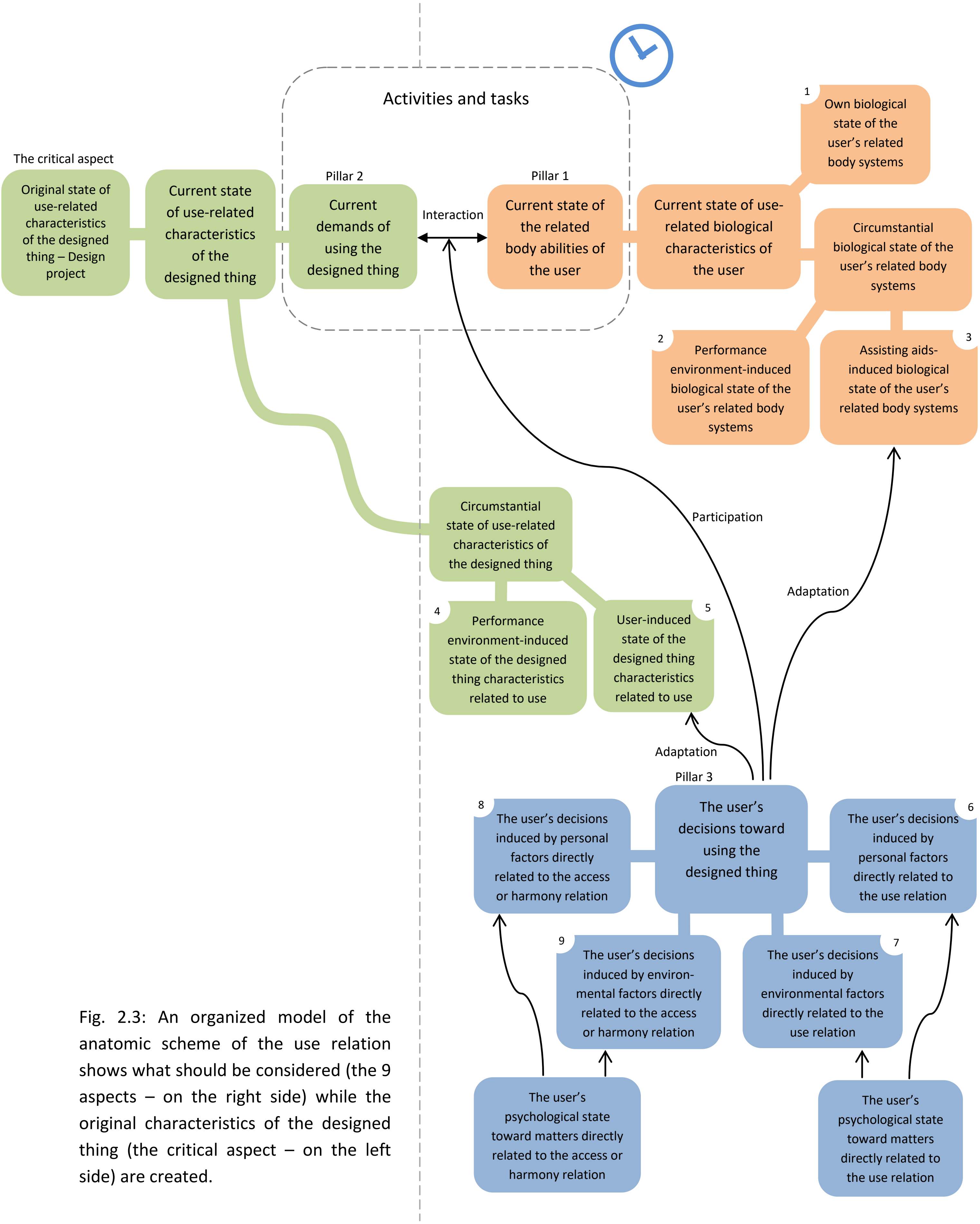


Fig. 2.3: An organized model of the anatomic scheme of the use relation shows what should be considered (the 9 aspects – on the right side) while the original characteristics of the designed thing (the critical aspect – on the left side) are created.

Contextual factors \ Concepts	The user's body abilities related to using the designed thing	The designed thing characteristics related to use	The user's decisions toward using the designed thing
Personal factors *directly* related to the use relation	✓ Aspect 1		✓ Aspect 6
Environmental factors *directly* related to the use relation	✓ Aspect 2	✓ Aspect 4	✓ Aspect 7
Personal factors *indirectly* related to the use relation			✓ Aspect 8
Environmental factors *indirectly* related to the use relation			✓ Aspect 9
	✓ Aspect 3	✓ Aspect 5	

Adaption

Adaption

Participation

Interaction

Table 2.1: The 9 aspects resulting from effects of the personal and environmental factors on the 3 main concepts.

2.4. Human body systems and body abilities:

The human body consists of many interacting body systems; each system contributes to the maintenance of homeostasis of itself, other systems, and the entire body (Wikipedia: Human body, Biological system). Systems don't work in isolation, and the well-being of the person depends upon the well-being of all the interacting body systems (ibid.). The circulatory, skeletal, integumentary, reproductive, digestive, urinary, respiratory, endocrine, lymphatic, muscular, nervous and immune systems are the widely studied human body systems (Innerbody.com). Some parts of different systems form together other body systems, e.g. the motor system (the neuromusculoskeletal system) consists of parts of the skeletal, muscular and nervous systems; and some systems consist of many sub-systems, e.g. the nervous system consists of sub-systems such as the cognitive system, neuroendocrine system and sensory systems (e.g. auditory and visual systems) – see the appendix '*Human body systems*'.

Each body system consists of a set of body structures interacting together to provide a main *body function* or *body ability* involving many *sub-functions* or *aspects*. This function helps the individual do the related tasks and actions (activities) of diverse life areas. For example, the visual system consists of the eyes, neural pathways and parts of the brain and their related structures; it provides the individual with the function of sight involving visual aspects, such as visual acuity, visual field, colour vision, contrast sensitivity and dark adaptation; and sight helps in reading, writing, watching TV, safely walking, etc. The International Classification of Functioning, Disability and Health (ICF), outlined by the World Health Organization (WHO), distinguishes between *body functions* and *body structures*; it defines body functions as the physiological functions of body systems – incl. psychological/mental functions being a part of brain functions, and body structures as anatomical parts of the body such as organs, limbs and their components (WHO: 2001, p. 10) – incl. brain.

Evaluating a body function (body ability) of an individual's body system – physiological state/ level of a body system (*physiological measures*) – is through evaluating its related aspects which express the performance state/level of the system structures singly and collectively based on the physical/anatomical state of the structures, not only on the *macroscopic level* but also on the *microscopic level* giving us more about the state of structure functions.[1] For

[1] Macroscopic/gross anatomy is the study of anatomical structures that can be seen by the naked eye; and microscopic anatomy is the field of histology which studies the organization of tissues at all levels, from cell biology to organs, and it involves the use of microscopes (optical instruments) to study minute anatomical structures (Wikipedia: Human body, Anatomy).

example, on the level of bones and muscles of the lower extremities system, evaluating the movement range of this system during walking or running doesn't depend only on the length of bones and size and shape of muscles (*macroscopic physical measures*) but also on bones density and muscles composition (*microscopic physical measures*); both measures affect in some way the movement range (*physiological measures*) of the lower extremities.

For this part of the study, considering the interaction between people and designed things – the using phase, 4 of the human body systems are of particular relevance, specifically: the *auditory*, *visual*, *cognitive* and *motor* systems. Any interaction with a designed thing typically requires a cycle where the user perceives, recognizes (conceptualizes or thinks) and acts (Clarkson, J.; Cardoso, C. and Hosking, I.: 2007, p. 186, 187 and Waller, S.). Perceiving and acting both require sensory and motor abilities – controlled by the brain (ibid.), and transforming sensory information into selected responses requires cognitive ability. For the most part, perceiving requires a sensory ability, recognizing requires a cognitive ability, and acting requires a motor ability (Waller, S.) – fig. 2.4. Limiting the study to the visual and auditory systems from the whole sensory systems[1] is because sight and audition involve many aspects and provide us with the majority of information about the world around us – incl. interaction with designed things – in most cases.

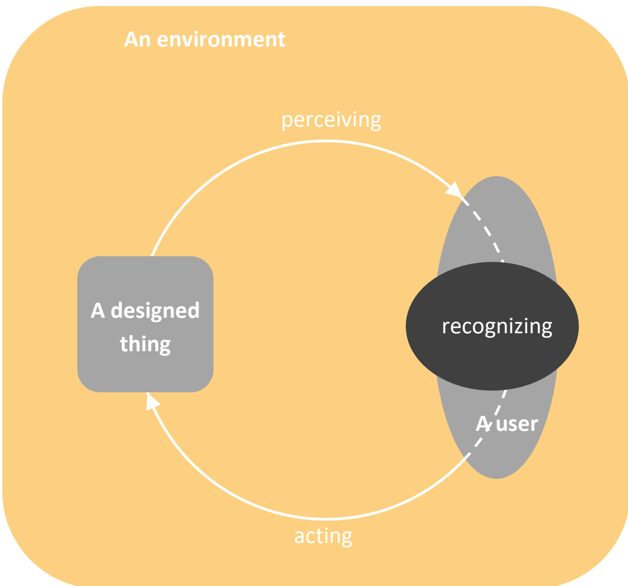


Fig. 2.4: The bodily interaction with a designed thing involves a cycle where the user's body abilities are used to perceive, recognize and then act.

[1] Sensory systems are divided into traditional and non-traditional sensory systems. The traditional ones include the visual/optical, auditory, gustatory, olfactory and somatic/tactile system expressing the traditional 5 senses respecttively: sight/vision, hearing/audition, taste/gustation, smell/olfaction, and touch/somatosensation; and the non-traditional sensory systems express the non-traditional senses such as thermoception (the sense of heat), balance (the equilibrioception/vestibular sense), proprioception (the kinesthetic sense) and nociception (the physiological pain). (Wikipedia: Sense; Innerbody.com)

Understanding more about those 4 body systems, their functions and related aspects, would be essential in the course of this study. The appendix '*Human body systems*' provides more information about those systems. From this appendix, it's concluded that:

- Each system consists of many structures and each structure plays a role in the whole function of the system.
- The visual, auditory, cognitive and motor systems provide individuals with the following body functions respectively:
  - **Sight**: It's the ability to sense the presence of light and sense the form, size, shape and colour of the visual stimuli (WHO: 2001, p. 62).
  - **Hearing**: It's 'the ability to sense the presence of sounds and discriminate the location, pitch, loudness and quality of sounds' (ibid.: p. 65).
  - **Cognition** (intellectual functioning): It's the ability of the human mind to process information, hold attention, store and retrieve memories, use reasoning skills and select appropriate responses and actions – decision-making (Ashok, M.: 2009, p. 4-6 and Waller, S.).
  - **Motion:** According to the body part being in action, the motion takes many forms. For this part of the study, 3 main forms of motion are of particular relevance:
    - **Locomotion**: It's 'the ability to move around, bend down, climb steps, and shift the body between standing, sitting and kneeling' (Waller, S.).
    - **Reach & stretch**: It's 'the ability to put one or both arms out in front of the body, above the head, or behind the back' (ibid.).
    - **Dexterity**: It's 'the ability of one or both hands to perform fine finger manipulation, pick up and carry objects, or grasp and squeeze objects' (ibid.).
- Each body function involves many related aspects or sub-functions as explained in the following – table 2.2:
  - **Sight** involves visual acuity, visual field, colour vision, contrast sensitivity, dark adaptation and disability glare.
  - **Hearing** involves sound detection, sound discrimination, speech discrimination, sound source localization and sound source discrimination.

- **Cognition**[1] involves perception, attention, memory, the mental function of language, calculation and intelligence (higher-level cognitive functions such as abstraction, insight, problem-solving, reasoning and decision-making).
- **Motion** involves structural support, range and ease of movement (flexibility), range of force production, range of muscle endurance, acceleration/deceleration ratio, peak velocity, movement duration/time, speed and accuracy, movement variability**,** force control and regulation, coordination, posture control and proprioception.

▪ The state of a function or an ability of a body system should be evaluated through all its aspects, not only one aspect; i.e. it shouldn't be reduced to one of its related aspects; e.g. the ability of an individual to see a photo can't be evaluated through measuring the clarity of details (visual acuity) without measuring detection of colours.

▪ The real state (physiological state) of a body system recognized through evaluating its function, reflects not only its visible anatomical/physical state (gross anatomy) but also the invisible one (microscopic anatomy) and the interaction state among its structures. So, the physiological measures – incl. cognitive ones – are very important because they provide information about what is invisible, thus, it will be easy to evaluate the body system correctly.

S	Visual S.						Auditory S.					Cognitive S.						Motor S.												
F	Sight						Hearing					Cognition						Motion (Locomotion, Reach & stretch, Dexterity)												
sub-functions or aspects	visual acuity	visual field	colour vision	contrast sensitivity	dark adaptation	disability glare	sound detection	sound discrimination	speech discrimination	sound source localization	sound source discrimination	perception	attention	memory	the mental function of language	calculation	intelligence (higher-level cognitive functions)	structural support	range and ease of movement (flexibility)	range of force production	range of muscle endurance	acceleration/deceleration ratio	peak velocity	movement duration/time	speed and accuracy	movement variability	force control and regulation	coordination	posture control	proprioception sense

S = Human body system
F = Human body function/ability

Table 2.2: Human body systems, body abilities/functions and their sub-functions or aspects

[1] Cognition is an intangible quality, which manifests itself tangibly in interactions with other people and with surrounding environments. (Ashok, M.: 2009, p. 4-6)

2.5. The user – The personal factors:

A user of a designed thing is a person who uses or physically/bodily interacts with this thing. The user as a human is an integrated context of numerous personal factors whose current features (absence, presence, values and/or qualities) make up his/her corresponding characteristics related to body, *skill*, *empowerment* and *ideology* which in turn make up his/her psychological and attitudinal characteristics. Personal factors refer to all aspects of the internal world that partly[1] form the context of an individual's life and, as such, have an impact on that person's functioning. Here, the personal factors represent the internal influences on the individual's ability level of using designed things – the impact of attributes of the user. As will be discussed in section 2.5.1, these factors can have a positive or negative impact on one or more of the *3 aforementioned concepts*[2]; thus, on the individual's ability of using this thing; and in turn, on the individual's performance while executing actions or tasks. In other words, the personal factors may act as facilitators or barriers while an individual is using a designed thing. These factors may be classified into 2 groups:

- **Personal factors *directly* related to the use relation (body- or skill-related personal factors):** They are personal factors that undoubtedly affect the 1st concept *'the user's body abilities related to using the designed thing'* on their way to affect the individual's ability of using designed things. They include ageing, impairment, sex, clinal affiliation, abnormality of body measures, nutrition, fitness, knowledge, education and profession[3] and *metaphorically* skill level (prior experience)[4]. By excluding the skill level, features of other personal factors make up the individual's biological (physical and physiological) characteristics – *body*-related characteristics; by including the skill level, features of these personal factors make up the individual's *body*- and *skill*-related characteristics.

[1] The other part is the environmental factors that refer to all aspects of the external world – see section 2.6.

[2] They are *the user's body abilities (body functions and structures) related to using the designed thing*, *the designed thing characteristics related to use*, and *the user's decisions toward using the designed thing*.

[3] – knowledge, education and profession from the perspective of their effects on the cognitive ability and skill level.

[4] Prior experience of using a designed thing or similar designed things or prior experience with other matters related to its use.

- **Personal factors *indirectly* related to the use relation (empowerment- or ideology-related personal factors):** They are personal factors that don't affect the 1st concept '*the user's body abilities related to using the designed thing*' on their way to affect the individual's ability of using designed things. They include income and wealth, political power, social status, geographical location, knowledge, education, profession[1], cultural identity and character style. Actually, these factors *directly* affect the individual's ability of accessing to or harmonizing with the designed thing. *Indirectly*, these factors may have effects on the user's ability of using a designed thing via their effects on the user-designed thing relations of access or harmony. Actually, features of these personal factors make up the individual's *empowerment*- and *ideology*-related characteristics.

The following shows the personal factors and their effects on the individuals' abilities of using designed things according to this classification.

[1] – knowledge, education and profession from the perspective of their effects on the person's empowerment.

2.5.1. Effects of the personal factors on the user's ability of using the designed thing:

2.5.1.1. Effects of the personal factors *directly* related to the use relation:

The personal factors *directly* related to the use relation are personal factors that undoubtedly affect the 1st concept *'the user's body abilities related to using the designed thing'* on their way to affect the individual's ability of using designed things. They include ageing, impairment, sex, clinal affiliation, abnormality of body measures, nutrition, fitness, knowledge, education and profession and *metaphorically* skill level (prior experience). Actually, features of these personal factors make up the individual's *body*- and *skill*-related characteristics.

1. Ageing[1]- Old age:

Ageing is the later part of normal life (Oxford Dictionary: Old age). It's the period of life after many other age phases. A human's life is divided into various age phases. These phases are infancy, childhood, preadolescence, adolescence, early adulthood, middle adulthood and late adulthood (old age). 'Although there are commonly used definitions of old age, there is no general agreement on the age at which a person becomes old. The common use of a calendar age to mark the threshold of old age assumes equivalence with biological age, yet at the same time, it is generally accepted that these two are not necessarily synonymous' (WHO: Definition of an older or elderly person). The United Nations (UN) hasn't adopted a standard numerical criterion for old age but generally uses *60+ years* to refer to the older population (ibid.). Because several psychological and physical changes becoming noticeable at the age of 60 or 65, many gerontologists stated that 60 or 65 years of age denotes the threshold age or the onset of old age (Bromley, D.: 1988).

With the wide range of old age (60+) and the very different accompanying conditions that people experience as they grow older within the years defined as old age – conditions starting from being fit, active, and able to care for themselves and ending by serious mental and physical debilitation – some gerontologists have recognized the diversity of old age by defining sub-groups to enable a more accurate portrayal of significant life changes (Wikipedia:

[1] Ageing (British English) or aging (American English) is the natural process of becoming older. Euphemisms and terms for old people include old people (worldwide usage), seniors (American usage), senior citizens (British and American usage), older adults (in the social sciences), the elderly, and elders (in many cultures including the cultures of aboriginal people) (Wikipedia: Old age).

Old age). One study divided older people into 3 groups: young old (60: 69), middle old (70: 79), and very old (80+) (Forman D.: 1992). A second sub-grouping is young-old (65: 74), middle-old (75: 84), and oldest-old (85+) (Zizza, C.: 2009). Other academics divided older persons into 4 groups: young old (60: 69 years old), middle-aged old (70: 79), old old (80: 89) and very old old (90+) (Burnside, I.: 1979). Another form of sub-grouping old people is according to the body abilities states; e.g. Gregor, Peter et al. (2002) divided older persons into 3 groups: 'fit older people who do not consider themselves nor appear disabled, but whose needs have changed with age; frail older people who have suffered a reduction in many of their functionalities, at least one of which may be considered a disability; disabled people who have aged, whose disabilities have affected their aging process making them dependent on other faculties that may also be declining' (Kurniawan, S.: 2009, p. 8-2). As each person is unique due to genetic and environmental factors, the body conditions that people experience as they grow older don't occur at the same chronological age for everyone, and they occur at different rates – gradual for some and precipitous for others – and different order for different people (Ohio State University Extension). Also 'every individual experiences the process in a different way, depending upon their gender, culture, education, geographical location, environment and the culmination of life events' (Department of Communities, Child Safety and Disability Services: 2012, p.4).

Effects of ageing on the user's ability level of using the designed thing:

A. The ageing phase may affect the user's ability of using a designed thing via affecting *the user's body abilities related to using the designed thing* (the 1st concept). Regardless of the chronological age, with ageing, everybody experiences many ageing-related biological changes (physical/anatomical and physiological changes) at a different age in his/her body parts, systems and functions. These changes are often degenerative and limited regenerative. In addition, old people often are more prone to disease[1], syndromes, and sickness than younger adults. With aging come declines in the levels of body abilities which may end with

[1] Most old persons have at least one chronic condition and many have multiple conditions. (Keates, S.: 2009, p. 5-3)

impairment or a condition of frailty[1]. Depending on several factors – a complex mixture of environmental[2] and genetic factors (Wikipedia: Ageing), the natural ageing process carries some degenerative changes in levels of body abilities, which can include varying degrees of hearing loss, diminished vision, motor and motor control impairments, as well as reduced attention, memory and intelligence functions (Myatt, E.: 2000 and Gregor, P.: 2002) (Kurniawan, S.: 2009, p. 8-1)[3]; where in general, the individual becomes less capable or unable to use things or complete tasks as would have normally been expected. Reduction or loss of a body ability and disability to do its related tasks of daily activities often come hand in hand. The appendix '*Ageing and the human body abilities*' shows some ageing-related biological changes in the human body abilities – sight, hearing, cognition and motion.

Actually, old people often record less level of the body abilities in comparison to their previous recorded level or of their younger counterparts. Statistics are more representative to express the role of ageing in changing the levels of body abilities. For example, John Clarkson presents a summary of the human body abilities data in 2 figures for the British populations aged between 16 and 49, and aged 75 and above; while the graphs have similar distributions, the percentage of those with a loss of capability in the 75+ age band is 10 times higher than for the 16: 49 band (Clarkson, J.: 2007, p. 171, 172). See fig. 2.5 and 2. 6.

Notes:

- 'Although it is apparent that most functional abilities decline with aging, some abilities (e.g. those related to semantic memory) do not decline until very late in life' (Kurniawan, S.: 2009, p. 8-8). In addition, various studies pointed out that older persons can perform some tasks equally well as younger persons do (ibid.).

---

[1] 'The condition of frailty among older adults is associated with increased vulnerability to adverse outcomes, including being at high risk for dependency, institutionalization, falls, injuries, acute illness, hospitalization, slow recovery from illness, and mortality' (Stoukides, J.: 2006, p. 4). It's distinguished by *bodily failure* and greater dependence becomes increasingly after that in the basic activities of daily living; with frailty, man loses the ability to do things essential to one's care (ibid.: p. 5). It's of higher frequency among women and more common in wealthier nations where greater support and medical care increase longevity (Collard, R.: 2012).

[2] The most notable environmental factors are the socioeconomic status and living conditions (Kurniawan, S.: 2009, p. 8-2)

[3] Although older persons suffer from degenerative changes in the body abilities accompanied with the ageing process, they shouldn't be categorized as people with impairments (ibid.: p. 8-1).

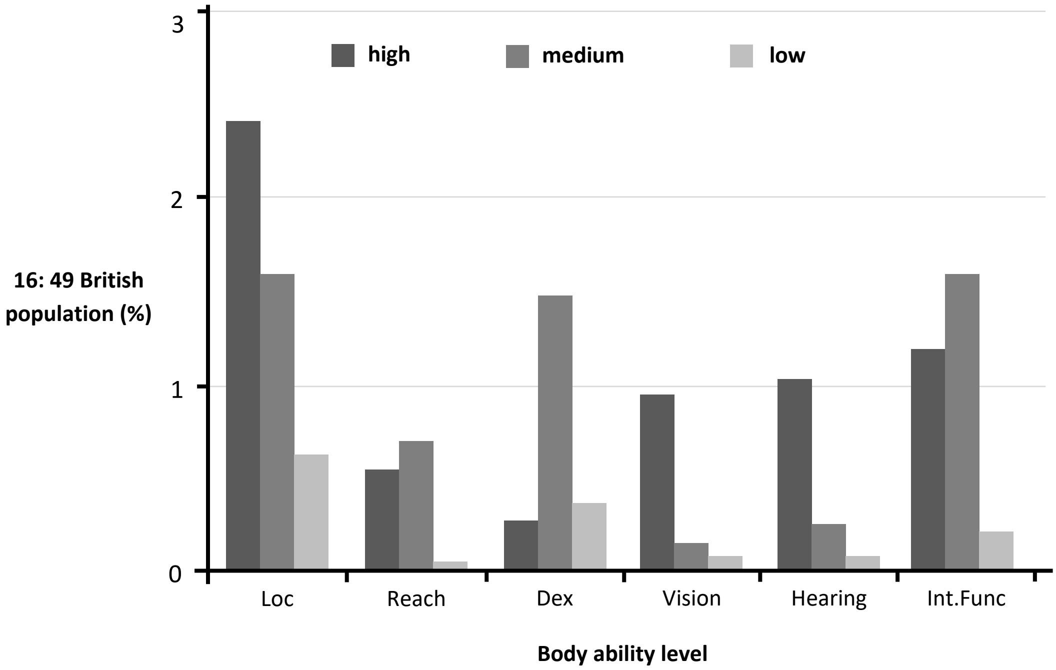


Fig. 2.5: Prevalence of loss of body capabilities within the British population aged between 16 and 49 (Clarkson, J.: 2007, p. 172)

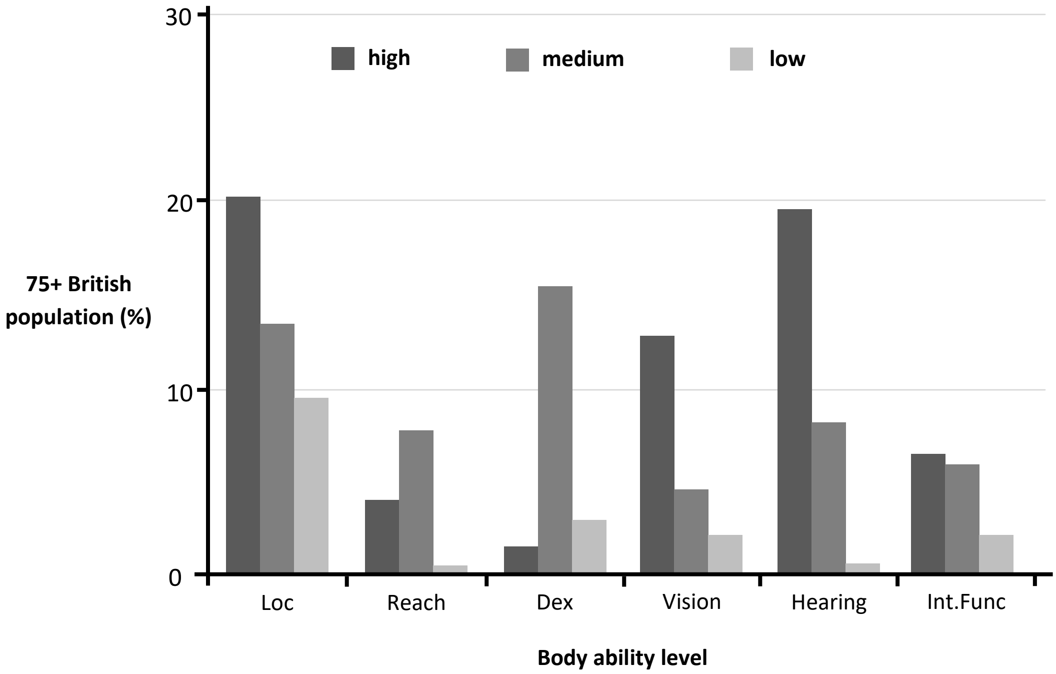


Fig. 2.6: Prevalence of loss of body capabilities within the British population aged 75 and above (Clarkson, J.: 2007, p. 172)

- Unfortunately, many older adults don't have solely a single functional decline, but several ones (Keates, S.: 2009, p. 5-3). 'In many cases, these are fairly minor losses of an individual's capabilities, but the minor losses can often have a cumulative effect. Thus, someone whose eyesight is not quite as sharp as it was, who keeps needing to turn the volume up a little bit louder on the television, and whose fingers are not quite as nimble as they once were, may find some products as difficult to use as someone with a single, but more severe, impairment' (ibid.: p. 5-4).
- The ageing-related declines over a wide range of the body abilities extended from sight and hearing to perception, attention, memory, intelligence and motion result in the general slowing of behavioural response (increasing of reaction time (RT) and movement time (MT)) which – beside lost strength – is a notable mark of older adults. Vercruyssen, M. suggested that older workers in machine-paced jobs have higher accident rates and fail to produce responses with sufficient speed (Vercruyssen, M.: 1997, p 70, 71); and Hawthorn, D. reported that older adults are less able to cope with demands for repetitive speed (Hawthorn, D.: 2000, p. 513).
- With the fact that skills accumulate with age, it has been acknowledged that the expertise factor of using things or doing tasks works to some extent as an advantage in resisting the related negative effects of ageing-related biological changes on using things or doing tasks related to this area of expertise – it resists the increasing demands on the related body abilities (Kurniawan, S.: 2009, p. 8-5). 'It seems that expert performance is maintained only over narrowly specific areas as skilled people age. Older chess players, typists and medical technologists retained high levels of performance in skills narrowly specific to their area of expertise while showing normal declines in areas such as reaction time and figure identification which might be argued to underlie their specific skills. ….. older architects and graphic designers continued to be acknowledged as experts but showed significant declines on measures of general visual thinking and imagery' (Hawthorn, D.: 2000, p. 521). See Hawthorn, D. (2000) for references confirming these findings.

According to the correlation between the level of body abilities and the level of abilities of using things a user has, and with changes in the body abilities level (the 1st concept) resulting from ageing, it can be concluded that ageing plays a significant role in affecting people's abilities levels of using designed things and doing everyday tasks.

B. The ageing phase may affect the user's ability of using a designed thing via affecting the 3rd concept '*the user's decisions toward using this thing*'. This can be attributed to the way a person adapts to and copes with his/her ageing process, and reflects it and all its accompanying matters on the use relation of this designed thing. Possible effects can be attributed to how the old user perceives the effects of the ageing process on matters related to the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user firstly perceives the effects of the ageing process on his/her body abilities related to using the designed thing (the 1st concept), his/her ability of using this designed thing or similar designed things, his/her abilities of doing their related tasks, differences than before regarding his/her body abilities level and abilities level of using this thing or doing its related tasks, and his/her differences from young adults (younger counterparts) regarding the body abilities level and abilities level of using this thing or doing its related tasks; and secondly reacts to them through actions regarding the *participation* and *adaptation*.

Participation affects the occurrence and activation of the use interaction, and with the recurrence of participation, it affects the buildup of the user's experience of using this thing, which in turn affects his/her ability of using it. *Adaptation* through modifying the designed thing characteristics related to use (incl. the normal method of use) – the 2nd concept, or modifying the user's body abilities related to using the designed thing (the 1st concept) by depending on assisting aids (incl. medical devices[1]), affects the 2 main pillars of the use relation and thus the quality of use interaction; adaptation aims to improve the ease of using the designed thing.

For instance, an old man may perceive his ageing working as a *disadvantage* while using a designed thing as an *activator* (a motivator for improvement) and try to adapt to this through modifying one or more of the use-related characteristics of this thing – incl. the normal method of using it[2], depending on assisting aids (incl. medical devices), or modifying one or more features of the performance environment when possible. In turn, these adapting actions would positively affect the 2 main pillars of use relation for this old man and thus his ability of using this thing, and the buildup of his experience of using it and consequently his

[1] – such as mobility aids (e.g. walking aids, seated walking scooters, wheelchairs and stairlifts), hearing aids (body worn, behind the ear and in the ear aids) and seeing aids (e.g. eyeglasses and corrective contact lenses).

[2] – through creating new strategies and sub-strategies to help in using it.

ability of using it. On the contrary, another old man may perceive his ageing working as a *dis-advantage* while using a designed thing as a *deactivator*[1] (a motivator for surrender); and he may be compelled to ineffectively, unsatisfactorily or dependently use this thing – especially with the impossibility of implementing the previous adapting actions; or he may avoid using it, never use it again, or on the extreme side, avoid using similar designed things. In turn, this would negatively affect the buildup of his experience of using it and consequently his ability of using it. Actually, life is full of examples of old people whose ages are their barriers to participation.

The same could be argued regarding the way an old individual perceives and reacts to his/ her differences (often negative values) from young adults regarding the body abilities level and the abilities level of using a designed thing or doing some tasks – as *activators* or *deactivators*.

A form of adaptation: To cope with the effects of the ageing process on matters related to the use relation, older adults modify their behaviour while using a designed thing or doing some tasks. The most notable behavioural change is increased cautiousness and lack of con-fidence (hesitancy about making responses that may be incorrect) resulting in taking more time to perform tasks but making fewer errors than younger people (Kurniawan, S.: 2009, p. 8-5) (speed-accuracy trade-off); in turn, it increases the general slowing of processing speed of older adults. Walker, N., Philbin, D. and Fisk, A. (1997) confirmed earlier studies showing that older people made more sub-movements (movement strategy) to compensate to an extent for both their reduced ability to produce acceleration force and their slower perceptual speed. Older people are more cautious in their movement strategies (Hawthorn, D.: 2000, p. 513). For example, Szlyk, J., Seiple, W. and Viana, M. (1995) found that older adults drove more slowly and made more eye movements and compensatory actions which translated into a lower real-world accident rate for older drivers despite the younger groups' faster responses.

A form of avoidance: Older adults show a *preference for the routine* (Lindauer, M.: 2003, p. 55, 56), and they have negative attitudes toward new or unfamiliar tasks or paradigm shifts in familiar tasks for them (Ashok, M.: 2009, p. 4-6). They may feel a sense of resistance to certain new tasks they haven't done before, which may reflect possible ageing-related problems in

[1] (frustrating factor)

adapting existing skills to new ones (Hawthorn, D.: 2000, p. 521, 522); Szlyk, J.; Seiple, W. and Viana, M. (1995) found that older adults showed poorer driving skills in a simulator than in their real world performance, which may suggest that older adults didn't adapt as well to a generally familiar task (driving) in a new setting (the simulator) (ibid.: p. 521); also, older people 'may feel a sense of resistance to certain technologies, especially when dealing with applications for tasks that people are used to completing without technology, such as online banking systems' (Ashok, M.: 2009, p. 4-11) and now, many older users are unable to manage the emerging multitude of technological innovations (ibid.). It may be concluded that older adults may avoid adding new burdens (increase demands) on their reduced body abilities, preferring to use retained skills they have learned before. This may be a possible reason for 'why older adults have poorer learning skills compared to younger adults' (Kurniawan, S.: 2009, p. 8-4). It has been shown that older adults can relearn old (previously learned) skills and learn novel skills, but at a much slower rate than young adults; skilled abilities such as coordination, balance, associative learning, and handwriting all improve with extended practice, although not always to the level of young adults; and older adults require more time to practice a skill before improvements are shown (Ketcham, C. J.: 2004).

Actually, perceiving and reacting to the effects of the ageing phase on matters related to the use relation are psychological matters, and they contribute to the individual's beliefs about what he/she can and can't do, and about what he/she can try to do and should avoid doing, which in turn form the required roles or responsibilities and expectations from him/her by others, or form some of the external attitudes[1] toward him/her by others. For instance, an old man who avoids using things that require a tight fist due to his low dexterity or his sureness that young adults have the preference while using these things contributes to the stereo-types about him by others regarding using these things and similar ones; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to him.

According to the correlation between the user's decisions toward using a designed thing (the 3rd concept) and the level of abilities of use he/she has, and with the effects of ageing-related psychological changes on these decisions, it can be concluded that ageing plays an additional significant role in affecting people's abilities levels of using designed things and doing daily tasks.

[1] – see section 2.6.1.1, no. 5.

In addition to ageing-related biological changes and their accompanying psychological and behavioural changes affecting the old people's abilities of using things and doing tasks, older adults also face other social issues such as retirement and reduction of family responsibilities (loss of previous roles), increased dependency with advanced age, loneliness[1], and ageism[2] (negative attitudes[3] toward old people because of their looks and behaviour). Such social issues mostly are results of the previous biological, psychological and behavioural changes of older adults. Actually, ageing in humans is a multidimensional process of biological, psychological and social change.[4]

To conclude, on an individual's level, and in the same conditions, with time, the ability level of using a designed thing is often variable due to the impact of advancing in age. On the collective level of individuals, in the same conditions and at a specific moment, people's abilities levels of using the same designed thing differ according to their different age phases. *Ageing* plays a significant role in what level of abilities of using designed things and doing tasks an individual has (in affecting people's abilities levels of using designed things), and it's a main personal factor of the *human dynamic diversity*. For actors, users aren't only the young and middle adults, even if true, they will *experience ageing marks* sooner or later.

[1] It's a mutual disengagement between people and their society willingly or due to the barriers to social engagement imposed by society (inability to make an active contribution to society).

[2] It's a form of discrimination or social prejudice against older people. For more, see Nelson, Todd D. (ed.): 2004, *Ageism: Stereotyping and Prejudice Against Older Persons*.

[3] For example, by using the *implicit-association test*, Banaji, Mahzarin R. and Greenwald, Anthony G. (2013) reported that 80% of Americans have an *automatic preference for the young over the old* and that attitude is true worldwide and that the young are *consistent in their negative attitude toward the old* (Banaji, M.: 2013, p. 67); Nelson, Todd D. (2004) documented that Americans generally have 'little tolerance for older persons and very few reservations about harboring negative attitudes' about them (Nelson, T.: 2004, p. ix); also, in his book *Aging and Old Age*, Posner, Richard A. (1997) discovers *resentment and disdain of older people* in American society (Posner, R.: 1997, p. 320).

[4] For more information about these tangled changes, see the 7 editions of the Handbooks of Aging consisting of 3 volumes: *Handbook of the Biology of Aging*, *Handbook of the Psychology of Aging*, and *Handbook of Aging and the Social Sciences*.

2. Impairment:

According to the WHO, impairments are problems in body function or structure such as an anomaly, defect, loss or other significant deviation (WHO: 2001, p. 12). They 'are those conditions caused when a particular part of the human body begins to function in an abnormal manner or loses its ability to function altogether, preventing a person from completing a task as would have normally been expected' (Ashok, M.: 2009, p. 4-2); e.g. an individual without a leg or with a paralyzed leg suffers from an impairment. 'Impairments represent a deviation from certain generally accepted population standards in the biomedical status of the body and its functions' (WHO: 2001, p. 12). The presence of an impairment necessarily implies a cause, it's the manifestation of that cause (ibid.: p. 13); it may be a genetic condition, or caused by trauma, injury, accidents, exposure to harmful environments, illness (Ashok, M.: 2009, p. 4-2) or ageing; e.g. loss of vision may arise from a genetic abnormality or an injury (WHO: 2001, p. 13)[1]. 'Impairments can be temporary or permanent; progressive, regressive or static; intermittent or continuous. The deviation from the population norm may be slight or severe and may fluctuate over time' (ibid.: p. 12). According to the defective body system, impairments take on many forms, such as motor and auditory impairments. In line with the 4 human body systems related to this study, the following briefly discusses the motor, auditory, visual and cognitive impairments.

- **Motor impairments:** They are those conditions caused when the motor system begins to function abnormally or loses its ability to function altogether. Problems in the movement -related aspects resulting from problems in functions of bones, joints, muscles or neural parts, are motor impairments. Problems in the structural support, range and ease of movement (flexibility), range of force production, range of muscle endurance, acceleration/deceleration ratio, peak velocity, movement duration/time, speed and accuracy, movement variability**,** force control and regulation, coordination, posture control or proprioception sense, are motor impairments – see the appendix '*Human body systems*', the motor system.

[1] Impairments are different than health conditions, the WHO defined *health conditions* as those that arise because of a disease or injury, such as, with multiple sclerosis (MS), joint-related pain due to arthritis, and so on (WHO: 2001, p. 3, 4). 'Impairments may be part or an expression of a health condition, but do not necessarily indicate that a disease is present or that the individual should be regarded as sick' (ibid.: p. 13) 'Impairments are broader and more inclusive in scope than disorders or diseases; for example, the loss of a leg is an impairment of body structure, but not a disorder or a disease' (ibid.: p. 13).

Conditions such as arthritis[1], osteoarthritis[2], osteoporosis[3], cerebral palsy[4], Parkinson's disease[5], MS[6], quadriplegia[7], stroke[8], spinal injuries and traumatic brain injury can give rise to symptoms that affect a person's motor abilities levels – see footnotes – and they are the most prevalent conditions expressing the motor impairments (Keates, S.: 2009, p. 5-1; Kurniawan, S.: 2009, p. 8-5 & Ashok, M.: 2009, p. 4-3). Symptoms of those conditions can be stable or highly variable, both within and among individuals, and can restrict the extent to which tasks are effectively accomplished (Keates, S.: 2009, p. 5-1); e.g. a person, who has a motor impairment of the knees, can't climb stairs when putting stress on them from an elevated position such as with climbing or descending stairs. Also, a person having a motor impairment of the hand fingers may not be able to position the mouse pointer over a small button or icon on a software interface, or activate a small button on a piece of hardware (ibid.: p. 5-5). A study commissioned by Microsoft found that 25% of working-age adults have some dexterity difficulty or impairment (Forrester Research: 2003). Anyway, people with motor impairments often have difficulties while doing many daily tasks.

---

[1] Arthritis is inflammation of joints causing pain, swelling and stiffness (Kurniawan, S.: 2009, p. 8-5). It results in pain, stiffness and difficulty in moving and performing regular tasks using joints; all varieties of arthritis cause difficulty in movement and debilitating pain in joints; the inability to freely and painlessly move joints in hands and fingers causes immense difficulty in using many designed things (Ashok, M.: 2009, p. 4-3). Rheumatoid Arthritis is a chronic systemic disease that affects the joints, connective tissues, muscles, tendons and fibrous tissue. It tends to strike during the most productive years of adulthood, between the ages of 20 and 40, and is a chronic disabling condition often causing pain and deformity. (WHO: Chronic rheumatic conditions)

[2] Osteoarthritis is a degenerative joint disease, which mainly affects the articular cartilage. It's associated with ageing and will most likely affect the joints that have been continually stressed throughout the years including the knees, hips, fingers and lower spine region. (WHO: Chronic rheumatic conditions)

[3] Osteoporosis is a loss of normal bone density, mass and strength, leading to increased porousness and vulnerability to fracture. (Kurniawan, S.: 2009, p. 8-5 and WHO: Chronic rheumatic conditions)

[4] Cerebral palsy is a neurological affliction that affects individuals from birth. It can result in impairment in muscle coordination, speech and learning. (Ashok, M.: 2009, p. 4-3 and Larson, H.: 2003)

[5] Parkinson's disease is a progressive disorder of the nervous system marked by muscle tremors and rigidity, decreased mobility, stooped posture, slow voluntary movements, and a masklike facial expression. (Kurniawan, S.: 2009, p. 8-5)

[6] MS is a disorder of the central nervous system marked by weakness, numbness, loss of muscle coordination and problems with vision, speech and bladder control. (Ibid.: p. 8-5)

[7] Quadriplegia is a disease in which affected individuals are paralyzed in their limbs as a result of spinal damage. Since most of the activities require the use of hands and legs, quadriplegic people are likely to encounter various problems while engaged in activities. (Ashok, M.: 2009, p. 4-3 and Larson, H.: 2003)

[8] Stroke refers to damage to the brain caused by interruption of its blood supply or leakage of blood outside of vessel walls. Depending upon where the brain is affected and the extent of the decreased blood supply to the brain, paralysis, weakness, speech defect, aphasia or death may occur. (Kurniawan, S.: 2009, p. 8-5)

- **Auditory impairments:** These are conditions caused when the auditory system begins to function abnormally or loses its ability to function altogether. Hearing loss may occur from an abnormality anywhere from the pinna to the auditory cortex (Turner, J. and Per-Lee, J.: 1990). Problems in the auditory functions such as problems in sound detection, sound discrimination, speech discrimination, sound source localization or sound source discrimination are auditory impairments – see the appendix '*Human body systems*', the auditory system. There are many reasons for loss of hearing, incl. heredity (genetics), loud sound exposure, trauma, diseases and infections, ageing and ototoxic drugs (drugs and chemicals that are poisonous to auditory structures) (Dobie, R.: 2004, p. 59; Ashok, M.: 2009, p. 4-5 and National academy on an aging society: 1999, p.2). Hearing loss is decreased perception of sounds (pure tone loss) and/ or diminished speech intelligibility (discrimination loss); a loss exceeding 30: 40 dB for the speech frequencies (300: 3000 Hz) is unacceptable for conversational communication (Turner, J. and Per-Lee, J.: 1990).

A reduction in the range of auditory frequencies or intensities that the healthy auditory system can detect is considered an auditory impairment[1]. The standard degree of impairment is defined and labeled in accordance with the ability to hear pure tones at 500, 1000 & 2000 Hz, and the degree of impairment is determined by the lost range of intensities measured in decibel; a hearing impairment is considered slight if the loss is from 16 to 25 dB, mild from 26 to 40 dB, moderate from 41 to 55 dB, moderately severe from 56 to 70 dB, severe from 71 to 90 dB, and profound if the loss is greater than 90 dB (Dobie, R.: 2004, p. 59 and Cook, A.: 1995).

Hearing loss can be categorized into 3 types: conductive, sensorineural or mixed (Dobie, R.: 2004, p. 59 and Turner, J.: 1990). Whereas the conductive loss is much more common than the sensorineural loss in children and adults to age 40; in adults, the sensorineural loss is statistically much more common (Turner, J. and Per-Lee, J.: 1990). Briefly, hearing loss is labeled conductive when a disease affects phase 1 structures and sensorineural when it affects phase 2 structures (ibid.) – see the appendix '*Human body systems*', the auditory system. In detail,

[1] The healthy, young auditory system can detect tones in quiet with frequencies ranging from approx. 20 to 20000 Hz (Dobie, R.: 2004, p. 48); taking into account that the majority of human speech sounds range from 300 to 3000 Hz (Turner, J. and Per-Lee, J.: 1990). In regards to the sound level, in the frequency region (between 500 and 4000 Hz) in which the human auditory system is most sensitive, the range of hearing covers approx. 130 dB (Dobie, R.: 2004, p. 48).

the conductive hearing loss occurs when the loss is due to problems with the outer or middle ear – loss in sound transmission from the outer to the inner ear, which can reduce a person's sensitivity to hear sounds below 60 dB (Dobie, R.: 2004, p. 59, 60 & Stein, L.: 1988), resulting in mild to moderate hearing impairment. Generally, with the conductive loss, the quality of hearing is still good, as long as the sound is amplified loud enough that it's conducted to the inner ear (Kinzel, E.: 2009, p. 6-8), when it's sufficiently amplified, it's clear and intelligible (Turner, J. and Per-Lee, J.: 1990). Also, it's very possible that hearing will return once proper care has been given to the ear (Ashok, M.: 2009, p. 4-5).

On the other hand, the sensorineural hearing loss (SNHL) occurs when the loss is due to problems with the cochlea, auditory cranial nerve or central auditory nervous system – problems associated with the neural transduction of sound – resulting in severe to profound impairment ranging from a drop in thresholds for a number of frequencies to the total loss of sensation (Dobie, R.: 2004, p. 60 and Stein, L.: 1988). Sensorineural loss is further divided into cochlear and retrocochlear categories; but, for the neurally impaired, cochlear is several times more common than retrocochlear loss (Turner, J. and Per-Lee, J.: 1990). In most instances of SNHL, the auditory nerve is intact and impairment in the hair cells within the inner ear results in hearing loss (Dobie, R.: 2004, p. 60). Hair cell damage at the base of the cochlea near the stapes causes high-frequency hearing loss, while hair cell loss away from the base (near the apex) leads to low-frequency hearing loss; the sensorineural hearing loss due to cochlear damage can occur at any frequency and can range from mild to profound (Dobie, R.: 2004, p. 60). Ageing, noise exposure, infections (viral or bacterial), disorders such as Meniere's disease and autoimmune inner ear disease, trauma, hereditary disorders and ototoxic drugs are causes of SNHL (ibid.: p. 60, 61).

Disease or damage in the sensorineural system reduces loudness and distorts sound quality (Turner, J. and Per-Lee, J.: 1990). Also, loss of acuity above 3000 Hz, often the only deficit seen in early sensorineural lesions, will generally affect discrimination of clarity of sound. This impairment is noted more in a noisy environment (ibid.).

Sensorineural hearing losses are more likely conditions of irreparable/irreversible hearing loss (Kinzel, E.: 2009, p. 6-8 & Ashok, M.: 2009, p. 4-5). Traditional acoustic amplification (hearing aids) is often ineffective at making speech sounds understandable to individuals with high -frequency hearing loss when the loss becomes severe. In individuals who have profound

SNHL across the frequency range, hearing aids may not be as effective in improving hearing as a cochlear implant. (Dobie, R.: 2004, p. 61)

Conditions such as presbycusis (a gradual[1], ageing[2]-related reduction in the ability to hear) and noise-induced hearing loss[3] are the most common conditions expressing hearing loss in adults. Because they arise commonly from the damage of the hair cells at the base of the cochlea, both can be categorized as SNHL. Both result in an inability to distinguish high -frequency sounds, such as the consonants of speech (such as 'S' and 'F') and children's and women's voices (Dobie, R.: 2004, p. 60 and National academy on an aging society: 1999, p.2). 'In individuals with these conditions, other parts of the inner ear still function, allowing for the normal perception of low-frequency sounds. As the conditions progress, middle and low -frequency hearing can also deteriorate' (Dobie, R.: 2004, p. 60).

Hearing loss may be temporary or permanent, depending on the nature of the condition (Ashok, M.: 2009, p. 4-5), with which listeners may experience a temporary or a permanent threshold shift for detecting sound compared to before the loss (Dobie, R.: 2004, p. 61).

Actually, loss of hearing is a serious type of sensory impairment that can significantly affect completing tasks effectively (Ashok, M.: 2009, p. 4-5); people with auditory impairment can experience challenges in their daily activities such as hearing phones, doorbells, and smoke alarms, responding to warnings, following conversations and socializing (Hearing loss can also make it hard to enjoy talking with family and friends, leading to feelings of isolation)[4] (NIDCD: 2014, Age-related hearing loss).

- **Visual impairments:** These are conditions caused when the visual system begins to function abnormally or loses its ability to function altogether. Problems in the visual functions – not fixable by usual means (e.g. glasses), such as problems in visual acuity, visual field, colour vision, contrast sensitivity, dark adaptation or disability glare are visual impairments – see

[1] Gradual hearing loss differs from congenital hearing loss, while the 1st happens over time, the 2nd means you are born without hearing (Hearing Loss Association of America: Basic Facts about Hearing Loss).

[2] Hearing loss that accumulates with age but is caused by factors other than normal ageing isn't presbycusis.

[3] It's caused by one-time exposure to extremely loud sounds, or by exposure to sounds at high decibels over months or years; examples of potentially hazardous noise include sounds from powerful stereos and head-phones, power tools, city and airport traffic, lawnmowers and even hair dryers and vacuum cleaners (National academy on an aging society: 1999, p.2).

[4] Hearing-related problems promote social withdrawal.

the appendix '*Human body systems*', the visual system. According to WHO, there are 3 levels of visual impairment: moderate visual impairment, severe visual impairment and blindness (WHO: 2014, Visual impairment and blindness). Moderate and severe visual impairments are grouped under the term '*low vision*' (ibid.). Conditions such as age-related macular degeneration (AMD)[1], uncorrected refractive error[2], cataract[3], glaucoma[4] and diabetic retinopathy[5] are the more common conditions expressing the visual impairments (Kinzel, E.: 2009, p. 6-3). Here, it should be noted that a defect in a single visual function is expressed in more than one condition, e.g. low visual acuity is a common symptom of refractive error, AMD and cataract – see the footnotes below. Actually, all of these forms of visual impairment can have dire consequences for interacting with surroundings. People with visual impairments can experience challenges in their daily activities such as reading, walking, driving, and socializing (CDC: Blindness and Vision Impairment). For example, individuals with vision less than 20/40 can't obtain an unrestricted driver's license in most states (ibid.); and individuals with central blind spots from macular degeneration or tunnel vision from glaucoma may find it difficult and tiring to read an entire computer screen (Kinzel, E.: 2009, p. 6-5, 6-6).

[1] AMD is a genetic disease; it's the most common cause of severe visual impairment among older people (Ford, M.: 1993). It refers to the breakdown or thinning of the most sensitive cells of the eye clustered in a small area in the centre of the retina known as the macula (Zarbin, M.: 1998), which is responsible for clear vision. The macular disease causes a progressive loss of central vision; sufferers still can see adequately at the peripherals of their vision (Ford, M.: 1993). While never resulting in total blindness, AMD is often severe enough for the sufferer to be classed as partially sighted or blind (Kurniawan, S.: 2009, p. 8-3).

[2] Refractive error (ametropia) is an error in how the light is refracted in the eyeball – an error in the focusing of light by the eye; nearsightedness (myopia), farsightedness (hyperopia) and astigmatism are types of ametropia (Wikipedia: ametropia)[2]. Another type of ametropia is presbyopia; it's an age-related disorder where the eyes exhibit a progressively diminished ability to focus on objects or detail at close distances (Kurniawan, S.: 2009, p. 8-3); it's caused by the gradual lack of flexibility in the crystalline lens of the eye due to the natural aging process – the crystalline lens becomes less capable of bending as we grow older[2] (St. Luke's Cataract & Laser Institute: Presbyopia; Schieber, F.: 2003, p. 45).

[3] Cataract refers to the loss of transparency, or clouding, of the lens of the eye and is predominantly an age -related disease (Spector, A.: 1982). It's caused by an accumulation of dead cells within the lens; and it's the most common cause of vision loss among people 55 and older (St. Luke's Cataract & Laser Institute: Cataract).

[4] 'Glaucoma is a group of diseases that can damage the optic nerve and cause blindness. …… Symptoms include loss of peripheral vision, starting with detail and increasing until the sufferers have a form of tunnel vision where they gradually lose all of their peripheral vision. If left untreated, this tunnel vision will continue to move inward until no vision remains' (Kurniawan, S.: 2009, p. 8-3). 'The sufferer has a decreased angle of vision and so must turn the head to view what a normal person could view in the peripheral vision' (ibid.: p. 8-3).

[5] Diabetic retinopathy 'is characterized by damage to the blood vessels in the retina, resulting from complications of diabetes mellitus' (Kinzel, E.: 2009, p. 6-5). It 'leads to blindness in some diabetic patients' (Ashok, M.: 2009, p. 4-5).

- **Cognitive impairments:** They are problems in the cognitive functions (perception, attention, memory, the mental function of language, calculation, intelligence and automated response)[1] – see the appendix '*Human body systems*', the cognitive system. 'They can arise in many ways, including brain injury or stroke; chromosomal abnormalities that affect the development of the brain (such as Down syndrome), producing developmental disabilities; severe mental illness; or effects of aging' (Lewis, C.: 2009, p. 7-1). Amnesia[2], Alzheimer's disease[3], dementia[4], Down syndrome, autism[5] and dyslexia[6] are the more common conditions expressing the cognitive impairments. Some of those conditions only express a defect in a single cognitive function, such as amnesia which expresses a memory deficit (Gazzaniga, M.: 2009, p. 382); and some express more than one defect in many cognitive functions, such as Alzheimer's disease which expresses a loss of memory, thinking and language skills, and behavioural changes (AFA). Also, a defect in a single cognitive function is expressed in more than one condition, e.g. loss of memory is a common symptom of Alzheimer's disease, as well as various forms of dementia and amnesia (Ashok, M.: 2009, p. 4-7).

  Actually, such conditions create a situation where the cognitive ability of the individual may be different from those who don't have the condition (Ashok, M.: 2009, p. 4-6). 'While all human beings possess some level of cognitive ability, the extent of this ability varies from person to person. This spectrum of variability makes it difficult to define the exact point of cognitive impairment, although it's possible to generally state that there is an accepted level of "normal" cognitive ability (Newell, A.: 2003). Levels of cognition that fall below this "normal" level are considered impaired states' (Ibid.: p. 4-6).

---

[1] They are broad headings, and each heading stands for a range of more specific functions; for more details, see (Lewis, C.: 2009, p. 7-3).

[2] Amnesia is a memory deficit caused by brain damage, disease, or psychological trauma (Gazzaniga, M.: 2009, p. 382).

[3] Alzheimer's disease is a progressive, degenerative disorder that attacks the brain's nerve cells, or neurons, resulting in loss of memory – problems in remembering recent events (short-term memory loss), thinking and language skills, and behavioural changes (AFA).

[4] Dementia 'is a syndrome in which there is deterioration in memory, thinking, behaviour and the ability to perform everyday activities' (WHO: 2015, Dementia). 'Although dementia mainly affects older people, it is not a normal part of ageing' (ibid.). Alzheimer's disease is the most common cause of dementia and may contribute to 60: 70% of cases (ibid.).

[5] Autism is a disorder of the central nervous system – a neurodevelopmental disorder – resulting in problems with verbal and non-verbal communication, imagination and social interaction (Ashok, M.: 2009, p. 4-5).

[6] Dyslexia is a brain-based type of learning disability that specifically impairs a person's ability to read despite normal intelligence (NINDS).

Effects of impairment on the user's ability level of using the designed thing:

A. The impairment may affect the user's ability of using a designed thing via affecting *the user's body abilities related to using the designed thing* (the 1st concept). As clarified in the previous 4 types of impairment, each one of them has a negative impact on its related body ability in some way, thus, on the user's ability level of using related designed things and doing related tasks. An impaired person becomes less able or unable to complete tasks related to his/her impairment as would have normally been expected. Actually, the higher, the degree of the impairment, the lower, the level of related body ability – sometimes down to zero – thus, the lower, the level of abilities of doing related tasks. Actually, impairment works as a disadvantage for those being impaired; significantly, it can negatively affect completing tasks effectively and impaired people can experience challenges in their daily activities. It can be concluded that impairment plays a significant role in affecting people's abilities levels of using designed things and doing everyday tasks.

B. The impairment may affect the user's ability of using a designed thing via affecting the 3rd concept '*the user's decisions toward using this thing*'. This can be attributed to the way an impaired person adapts to and copes with his/her impairment, and reflects it and all its accompanying matters on the use relation of this designed thing. Possible effects can be attributed to how the impaired user perceives the effects of his/her impairment on matters related to the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user firstly perceives the effects of impairment on his/her body abilities related to using the designed thing (the 1st concept), his/her ability of using this designed thing or similar designed things, his/her abilities of doing their related tasks, differences than before[1] regarding his/her body abilities level and abilities level of using this thing or doing its related tasks, and his/her differences from unimpaired/able-bodied people regarding the body abilities level and abilities level of using this thing or doing its related tasks; and secondly reacts to them through actions regarding the *participation* and *adaptation*[2].

[1] – when impairments are non-congenital.

[2] *Participation* affects the occurrence and activation of the use interaction, and with the recurrence of participation, it affects the buildup of the user's experience of using this thing, which in turn affects his/her ability of using it. *Adaptation* via modifying the designed thing characteristics related to use (incl. the normal method of use) – the 2nd concept, or modifying the user's body abilities related to using the designed thing (the 1st concept) by depending on assisting aids (incl. medical devices), affects the 2 main pillars of the use relation and thus the quality of use interaction; adaptation aims to improve the ease of using the designed thing.

For instance, an impaired man may perceive his impairment working as a *disadvantage* while using a designed thing as an *activator* (a motivator for improvement) and try to adapt to this through modifying one or more of the use-related characteristics of this thing – incl. the normal method of using it, depending on assisting aids (incl. medical devices), or modifying one or more features of the performance environment when possible. In turn, these adapting actions would positively affect the 2 main pillars of use relation for this impaired man and thus his ability of using this thing, and the buildup of his experience of using it and consequently his ability of using it. On the contrary, another impaired man may perceive his impairment working as a *disadvantage* while using a designed thing as a *deactivator* (a motivator for surrender); and he may be compelled to ineffectively, unsatisfactorily or dependently use this thing – especially with the impossibility of implementing the previous adapting actions; or he may avoid using it, never use it again, or on the extreme side, avoid using similar designed things. In turn, this would negatively affect the buildup of his experience of using it and consequently his ability of using it. Actually, life is full of examples of impaired people whose impairments are motivators to do their best, and others whose impairments are causes of frustration which increases their sufferance and sometimes leads to depression[1].

The same could be argued regarding the way an impaired individual perceives and reacts to his/her differences (often negative values) from able-bodied people regarding the body abilities level and abilities level of using a designed thing or doing some tasks – as *activators* or *deactivators*.

Actually, perceiving and reacting to effects of the impairment on matters related to the use relation are psychological matters, and they contribute to the impaired's beliefs about what he/she can and can't do, and what he/she can try to do and should avoid doing, which in turn form the required roles or responsibilities and expectations from him/her by others, or form some of the external attitudes[2] toward him/her by others. For instance, an impaired man who avoids using things which require a tight fist due to his low dexterity or his sureness that able-bodied people have the preference while using these things contributes

[1] Much of the research seems to emphasize the role that negative emotions play in the psychology of impaired people and how this may affect the way in which they experience their impairment Depression seemed to be commonly associated with physical impairment. (Supple, S.: 2005, p. 418)

[2] – see section 2.6.1.1, no. 5.

to the stereotypes about him by others regarding using these things and similar ones; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to him.

In addition to low levels of body abilities related to impairment and their accompanying psychological and behavioural issues affecting the impaired people's abilities of using things and doing tasks – especially having permanent and severe impairments, those people also face other social issues, such as reduction of responsibilities[1], dependency, loneliness, and ableism[2] (negative attitudes toward impaired people because of their abilities, looks and behaviour)[3]. Such social issues mostly are results of the low levels of body abilities and their accompanying psychological and behavioural issues of impaired people. Actually, impairment in humans is a multidimensional domain of biological, psychological and social matters.

To conclude, *impairment* plays a significant role in what level of abilities of using designed things and doing tasks an individual has (in affecting people's abilities levels of using designed things), and it's a main personal factor of the *human dynamic diversity*. For actors, users aren't only the able-bodied people, impaired people are around us everywhere; even the able-bodied people may become impaired at some point in their life – temporarily or permanently; anyone is susceptible to being impaired even temporarily – e.g. an individual with a broken hand or leg is temporally impaired.

[1] – accompanying to the non-congenital impairments.

[2] Ableism or ablism is a form of discrimination or social prejudice in favour of able-bodied people (Oxford Dictionary: Ableism). The ableist societal world-view is that the able-bodied is the norm in society and the impairment is an error, a mistake or a failing, rather than a simple consequence of the human diversity, akin to race, ethnicity, sexual orientation or gender (Marshak, L.: 2010, p. 50).

[3] Impaired people have unequal rights to education, employment, and cultural life; to own and inherit property; to marry, etc. For example, 'the majority of the working-age population — age 18 to 64 — with hearing loss is employed, but hearing difficulties can affect the kind and amount of work they do, and whether they work at all. Labor force participation rates are lower for people with hearing loss than for others. Some 67 percent of the working-age population with hearing loss is employed, compared to 75 percent of the working age population without hearing loss. In addition, close to 13 percent of workers age 51 to 61 with hearing loss report that hearing loss limits the type or amount of paid work they can do' (National academy on an aging society: 1999). Also, 'among people age 51 to 61, about 18 percent of those with hearing loss are completely retired, compared to just 12 percent of those who do not have hearing loss. Health status appears to be a strong factor in retirement decisions for people with hearing loss' (ibid.).

3. Sex:

Sex refers to the biological distinction between females and males (Knox, D.: 2011, p. 39). Human sex refers to the biological characteristics that define human females and males (WHO: What do we mean by sex and gender?). It represents the physical and physiological differences between human females and males. The physical sex differences 'are rather obvious and most of these can be seen and easily measured' (Conner, M.: 1999-2000). Weight, shape, size and anatomy are tangible and easily measured (ibid.). Actually, the physical differences are differences in body structures and they are divided into *primary* and *secondary* differences.

Primary physical sex differences are the direct result of differences prescribed by 5 factors present at birth and determining the biological sex: the presence or absence of a Y chromosome, the type of gonads, the sex hormones, the internal reproductive anatomy (such as the uterus in females), and the external genitalia (Knox, D.: 2011, p. 39). The primary physical sex differences are radical; they are features related to the reproductive role – are directly necessary for reproduction to occur – provide completely different body functions and take place immediately as the male or female begins to develop within the womb.

As for *secondary physical sex differences*, they are features that appear during puberty but aren't directly part of the reproductive system (Wikipedia: Secondary sex characteristics). Inversely to the primary physical differences, secondary ones are differences in common features between human males and females – in common body structures. Except for the external genitals, there are rather few differences between girls and boys until they reach puberty; there are small differences in height, and there are differences in the rate at which children become mature: girls reach half their eventual adult weight at an earlier age than boys, and their adult teeth come through slightly earlier, but there's considerable overlap and similarity between girls and boys in the first decade of life (Birke, L.: 2001, P. 312). General habitus and shape of body and face, as well as sex hormone levels, are similar in prepubertal boys and girls; as puberty progresses and sex hormone levels rise, differences appear, though puberty causes some similar changes in the male and female bodies (Wikipedia: Secondary sex characteristics). Secondary physical sex differences in humans include the presence or absence of the breast and the menstrual cycle, and differentiation of muscles mass, size (height and weight), appearance, Adam's apple, hair distribution, length of vocal cords, bone density, pelvis shape, skin nature, fat percentage in the body, etc. Such differences are quantified by empirical data and statistical analysis and vary across societies.

The physical differences between human males and females provide functional advantages and have survival value (Conner, M.: 1999-2000). Sex differences in human physiology (physiological sex differences) are distinctions of physiological characteristics associated with either male or female humans. 'They are differences in the ways that our bodies work' (Birke, L.: 2001, p. 315). While the primary physical sex differences being radical provide completely different body functions, the secondary ones being differences in common features between males and females – differences in common body structures (physical measures) – provide the same body functions (body abilities) but in different values (physiological measures) or other ways. 'This includes the amount of oxygen that the blood can carry, or muscle strength and weight, for example. Differences between males and females in muscle width of arms and calf seem to increase at puberty, although this is less true of other muscles. There is only a small difference between women and men, on average, in the size or strength of muscles in the thigh (allowing for differences in body size; a bigger person obviously has bigger muscles)' (ibid.: p. 315).

These *secondary physical and physiological sex differences* lead *directly* to differences between them in related body abilities levels; in turn, *directly* to differences between them in abilities levels of doing the related same task. A sex-related human body measure may promote a human sex while doing a task or prevent him/her from completing it or effectively doing it as the other sex. This mustn't be evidence of superiority or inferiority between men and women, but evidence of field specializations[1], distribution of tasks and integration for perfection. Excluding tasks related to the reproductive role, able-bodied men and women in the same conditions can perform the same tasks; the difference is the ability level of doing them which changes according to the *secondary sex-related differences*. For example**,** differences in intake and delivery of oxygen translate into some aspects of performance:

[1] More men work in the following industries: mining, construction, transportation, farming, engineering and architecture, computer and mathematical occupations, chief executives, firefighters, police and patrol officers, electricians, dentists and surgeons. Women are far more likely than men to be social workers, paralegals and legal assistants, teachers, nurses, speech pathologists, dental hygienists, maids and housekeeping cleaners and childcare workers. (steadyhealth.com/articles/difference-between-male-and-female-structures-mental-and-physical)

when a man is jogging at about 50% of his capacity, a woman will need to work at over 70% of her capacity to keep up with him[1]. Also, greater men's bodies help them perform tasks requiring hard efforts easily than women; smaller women's hands promote them in effectively performing tasks requiring accuracy than men; more expanded auditory and language-related regions in the left hemisphere of women's brains help them effectively perform tasks requiring communication than men. Thus, it can be concluded that *sex* plays a significant role in affecting people's abilities levels of doing tasks. Actually, secondary physical and physiological sex differences are so important when we think about required tasks to be done; many references[2] show the secondary physical sex differences (incl. brain ones), and their related secondary physiological sex differences (incl. cognitive ones). These differences aren't absolute; they describe how men and women are in most situations most of the time.

Effects of sex on the user's ability level of using the designed thing:

A. Sex may affect the user's ability of using a designed thing via affecting *the user's body abilities related to using the designed thing* (the 1st concept). A sex-related human body measure has an impact on its related body ability in some way, thus, on the ability level of using related designed things and doing related tasks. An individual of either sex with a sex -related body measure may record higher or lower body abilities levels in comparison to recorded levels of the other sex while using the same designed thing. For example, considering dexterity and the fact that the dimensions of women's hands are smaller than men's hands[3], while some women may face some problems in catching and controlling the big handles of woodworking, farming and gardening tools, thus in completing related tasks as

[1] steadyhealth.com/articles/difference-between-male-and-female-structures-mental-and-physical

[2] For example, see: Ellis, Lee et al.: 2008, Sex differences: summarizing more than a century of scientific research; Birke, Lynda: 2001, In Pursuit of Difference: scientific studies of women and men, pp. 309-321; and Ogden, Cynthia L. et al: 2004, Mean Body Weight, Height, and Body Mass Index, United States 1960–2002.

[3] A study conducted in the Department of Forensic Medicine & Toxicology, SSR Medical College, Mauritius in the year 2005 on a group of 250 young and healthy students (125 males and 125 females) in the age of 18: 30 years, showed that (Agnihotri, A.: 2005):

> In males, the right hand length varied from 15.3cm to 21cm (mean 18.89cm) and left hand length varied from 15.4cm to 20.08cm (mean 18.9cm). In females, the right hand length varied from 14.8cm to 20.4cm (mean 17.22cm) and left hand length varied from 14.8cm to 20.4cm (mean 17.22cm).
>
> In males, the right hand breadth varied from 7.3cm to 9.4cm (mean 8.45cm) and left hand breadth varied from 7.2cm to 9.4cm (mean 8.42cm). In females, the right hand breadth varied from 6.7cm to 8.8cm (mean 7.48cm) and left hand breadth varied from 6.6cm to 8.7cm (mean 7.42cm).

would have normally been expected, some men may show higher levels of dexterity in using tools with big handles. Conversely, while some women may show higher levels of dexterity in using fine tools, keys of small mobile phones, touch screens of small handheld computing tools or small laptops keyboards, some men may find difficulty in perfectly using fine tools. From the previous, a sex-related body measure may be an advantage or a disadvantage for a person; while the hand size of a male/female affects negatively his/her ability of using some designed things (thus, doing their related tasks), it affects positively his/her ability of using other designed things; the sex-related body measure doesn't have a negative or positive effect all the time but according to the nature of each designed thing or each task[1]. That's to say, sex as a personal factor differs from some other personal factors (such as ageing and impairment) often having negative effects on the body abilities levels (on the physical and physiological body measures), thus, on abilities levels of using related designed things.

B. Sex may affect the user's ability of using a designed thing via affecting the 3rd concept '*the user's decisions toward using this thing*'. This can be attributed to the way an individual of a specific sex adapts to and copes with his/her sex, and reflects it and all its accompanying matters on the use relation of this designed thing. Possible effects can be attributed to how the user perceives the effects of his/her sex on matters related to the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user firstly perceives the effects of his/her sex (own sex characteristics) on his/her body abilities related to using the designed thing (the 1st concept), his/her ability of using this designed thing or similar designed things, his/her abilities of doing their related tasks, and his/her differences from others having different sex regarding the body abilities level and abilities level of using this thing or doing its related tasks; and secondly reacts to them through actions regarding the *participation* and *adaptation*[2].

---

[1] For example, taking the body fat percentage as a sex-related body measure, the fact that women tend to have more body fat has sometimes been seen as a disadvantage regarding sport – more weight to carry and smaller muscles, for instance. But this difference can also be interpreted another way: fat is an excellent source of stored energy and is a good insulator. So for long-distance running, women might have an advantage over men in having more ready access to long-term stores of energy. (Birke, L.: 2001, p. 316)

[2] – see the footnotes in p. 74.

For instance, an individual may perceive his/her sex as an *activator* when it works as a *disadvantage* while using a designed thing and tries to adapt to this through modifying one or more of the use-related characteristics of this thing – incl. the normal method of using it, depending on assisting aids, or modifying one or more features of the performance environment when possible. In turn, these adapting actions would positively affect the 2 main pillars of use relation for this man and thus his ability of using this thing, and the buildup of his experience of using it and consequently his ability of using it. Conversely, another individual of the same sex may perceive it as a *deactivator* when it works as a *disadvantage* while using the same designed thing; and he/she may be compelled to ineffectively, unsatisfactorily or dependently use this thing – especially with the impossibility of implementing the previous adapting actions; or he/she may avoid using it, never use it again, or on the extreme side, avoid using similar designed things. In turn, this would negatively affect the buildup of his/her experience of using it and consequently his ability of using it. For example, a woman who finds difficulties in using (catching and controlling) a hummer or a boring machine due to her hand size may avoid using them, never use them again, or avoid using similar ones. Actually, life is full of examples of people whose sex working as disadvantages are motivators to do their best, and others whose sex working as disadvantages are causes of frustration. On the other hand, an individual may perceive his/her sex as an *activator* when it works as an *advantage* while using a designed thing (a motivator for progress, distinction and superiority), which may positively affect his/her decisions toward using it, such as preferring to use it; which in turn, positively affects the buildup of his/her experience of using it and consequently his/her ability of using it. Conversely, another individual of the same sex may perceive it as a *deactivator* when it works as an *advantage* while using the same designed thing (a motivator for laziness, slouching, slackness or carelessness), which may have a negative effect on the buildup of his/her experience of using it and consequently his/her ability of using it.

The same could be argued regarding the way an individual perceives and reacts to his/her sex differences (whether they are positive or negative values) from others having different sex regarding the body abilities level and abilities level of using a designed thing or doing some tasks[1] – as *activators* or *deactivators*.

Actually, perceiving and reacting to effects of the sex on matters related to the use relation are psychological matters, and they contribute to the beliefs of the individual being with a

[1] A human sex is the upper and the other sex is the lower in using a designed thing or doing a specific task.

specific sex about what he/she can and can't do, and what he/she can try to do and should avoid doing, which in turn form the required roles or responsibilities and expectations from him/her and from other sex by others, or form some of the external attitudes[1] toward him/her by others. For instance, a woman who avoids using tools with big handles or to do woodworking and gardening tasks due to her hand size or her sureness that men have bigger hands and have a preference while using these tools, contributes to the stereotypes about her by others regarding using these tools and similar ones; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to her.

In addition to the distinction of body measures (sex biological differences – incl. ones of the brain) and their accompanying psychological and behavioural issues affecting negatively or positively the abilities of using things and doing tasks, males and females also face other social issues, such as dependency and sexism[2] (negative or positive attitudes toward a sex in favour of the other sex because of their abilities, looks and behaviour – attitudes as stereotypes, gender roles[3], and inequality in rights[4]). Actually, sex in humans is a multidimensional domain of biological, psychological and social matters.

To conclude, *sex* plays a significant role in what level of abilities of using designed things and doing tasks an able-bodied individual has (in affecting people's abilities levels of using designed things); and it's a main personal factor of the *human diversity*. For actors, men and women have countless different secondary body measures and both perform countless similar activities and tasks.

[1] – see section 2.6.1.1, no. 5.

[2] Sexism is prejudice or discrimination based on sex, typically against women and girls through ideological and material practices of individuals, collectives, and institutions that oppress women and girls based on sex or gender (Encyclopaedia Britannica: Sexism).

[3] A gender role is a set of societal norms dictating the types of behaviours which are generally considered acceptable, appropriate or desirable for people based on their actual or perceived sex or sexuality. Gender roles are usually centred on conceptions of femininity and masculinity, although there are exceptions and variations. The specifics regarding these gendered expectations may vary substantially among cultures, while other characteristics may be common throughout a range of cultures. There's ongoing debate as to what extent gender roles and their variations are biologically determined, and to what extent they are socially constructed. (Wikipedia: Gender role)

[4] – in education, workplace, income, etc; e.g. Eurostat (the Directorate-General of the European Commission) found a persistent, average gender pay gap of 16.4% in the 27 EU member states in 2012; it found 'that there are considerable differences between the Member States in this regard, with the gender pay gap ranging from less than 10% in Slovenia, Malta, Poland, Italy, Luxembourg and Romania, to more than 20% in Hungary, Slovakia, the Czech Republic, Germany and Austria, and reaching 30% in Estonia.' (European Commission)

4. Cline – Clinal affiliation:

The majority of a human population – people who have lived in the same geographic region for many generations, have some *traits* in common that *distinguish* them from other populations; this appears to be universally true for all human populations anywhere in the world – see the following debate. A trait is 'a distinct *phenotypic* character, which may be either heritable or environmentally determined or both' (Lawrence, E.: 2005, *trait*, p.667); e.g. hair colour is a character or abstraction of an attribute, while black, brown and blond are traits. The phenotype is the physical characteristics of the organism (Wikipedia: Phenotypic trait). An organism's phenotype includes its physical appearance, internal anatomy, physiology, and behaviour (Reece, J.: 2011, ch. 14 – concept 14-3). The trait is the expression of genes (the behaviour of genes) in an observable way; it's controlled by the genetic make-up of the organism and the environmental pressures the organism is subject to (ibid.). The phenotype for a character depends on the environment as well as the genotype; e.g. hydrangea flowers of the same genotype range from blue-violet to pink, depending on soil acidity (ibid.). Also, mice given some dietary supplements have changes affecting the expression of the agouti gene, which affects their fur colour, weight, and propensity to develop cancer (Cooney, C.: 2002 and Waterland, R.: 2003). The diversity of traits of a character describes how much that character tends to vary in response to genetic and environmental influences – hereditary and environment. While the genetic influence on organisms' phenotype is studied under *genetics*, the environmental one is studied under *epigenetics*.[1]

Obviously, genes aren't the only factors that determine phenotype (Lobo, I.: 2008); many studies have shown that[2] the environmental ones play a role in the production of traits of organisms. Genes aren't everything when it comes to determining the characteristics of an organism (Ralston, A.: 2008). The individuality and variation we observe in each organism's traits (phenotypes) are 'generated through a complex interaction between the organism's complete genetic endowment and its environment from conception onward' (Lobo, I.: 2008).

[1] Epigenetics is the study of heritable changes in gene *activity* that aren't caused by changes in the DNA sequence (the genotype), in plainer language, epigenetics is the study of changes in the *expression of genes* (Wikipedia: Epigenetics) which have been observed to occur in response to environmental exposure (Spector, T.: 2012). Epigenetics describes processes by which modifications in gene function that can be inherited by a cell's progeny occur without a change in DNA nucleotide sequence; such modifications include DNA methylation, heterochromatin formation, genomic imprinting, paramutation, X-chromosome inactivation (Lawrence, E.: 2005, Epigenetics, p. 208).

[2] For Example, see: Reece, Jane B.: 2011; Lobo, Ingrid: 2008; Ralston, Amy: 2008 and Spector, Tim: 2012.

> *'Scientists have long appreciated the role that environmental factors play in the production of traits in animals. Environmental factors such as diet, temperature, oxygen levels, humidity, light cycles, and the presence of mutagens can all impact which of an animal's genes are expressed, which ultimately affects the animal's phenotype. ……. pointing to the power of subtle environmental differences on gene expression.'* (Ralston, A.: 2008)
>
> *'Environmental factors are certainly critical in defining phenotypes during early development, ……., and they continue to influence phenotypes throughout an organism's life cycle. Nearly every aspect of our development and behavior is affected by both the personal experiences we gain through our environment and our genetic makeup. For example, we obtain necessary amino acids through our diets, and the incorporation of these nutrients into our bodies is determined by our genes. It is also important to remember that genes are not a steadfast blueprint for heredity. Genes are actually quite active throughout our lives, switching their expression on and off in response to the environment and experience. Environmental factors can affect and alter gene expression, while our genes can define how we respond to different environments.'* (Lobo, I.: 2008)

While an organism's genetic makeup plays a critical role in its development, there's also a rich and complex interplay between the genome and cues from the environment – between nature (heredity) and nurture (environment). In reality, the relationship between genetic determinants and the environment is so completely entwined that you can't look at an individual and judge which contribution is more *valuable*. Together, the continual interplay of both genes and the ever-changing environmental factors determines who we are. (ibid.)

One way to examine the role of the environment in variation among organisms is to compare the phenotypes of various traits in genetically identical organisms (who are indeed the same at the genetic sequence level), like twins or, even better for research purposes, quadruplets (ibid.). The observation that genetically identical organisms often vary greatly in phenotype clearly shows that *gene-environment interaction* is indeed an important regulator of phenotypic variation (Ralston, A.: 2008). This has led to the conclusion that both genes and environments influence organisms' traits (phenotype) – not just separately, but via direct interaction with each other (ibid.).[1]

[1] Although the differences between twins can't yet be attributed to specific epigenetic processes, animal -behaviour studies suggest that this is plausible (Spector, T.: 2012). In his book 'Identically Different: Why you can change your genes' (2012), *genetic epidemiologist*, Tim Spector argues that identical twins offer a unique opportunity to understand the mysterious process in which human personality traits apparently governed by

Clinal affiliation: Again, the majority of a human population have some *traits* in common; this can be attributed to – according to the previous debate – the similarity of their genes expression resulting from, first: *frequencies* (centralization) of some specific alleles[1] (forms of genes) in the gene pool[2] of these people, and second: *subjecting to the same environmental factors*, e.g. geographical factors as temperature, moisture, etc. When people share the genetic background and environmental factors, the average human body measures is frequently characteristic within the group (Wikipedia: Human height). Thus, it can be concluded that differences across populations in traits result from the differences among them in frequencies of genes expression. In 1978, Sewall Wright argued that it doesn't 'require a trained anthropologist to classify an array of Englishmen, West Africans, and Chinese with 100% accuracy by features, skin color, and type of hair in spite so much variability within each of these groups that every individual can easily be distinguished from every other' (Wright, S.: 1978, p. 439). 'Anthropologists long ago discovered that humans' physical traits vary gradually, with groups that are close geographic neighbors being more similar than groups that are geographically separated' (Ossorio, P.: 2005, p.116) – are gradually variable over geography. This pattern of variation is known as *clinal variation* (ibid.).

The Human Genome Project (HGP)[3] states that 'people who have lived in the same geographic region for many generations may have *some alleles in common*, but no allele will be

---

genes may change in response to crucial life experiences through *epigenetics* — chemical modifications of the genome and certain associated proteins. He focuses on case studies of identical twins because they are a well -trodden way of exploring how environmental triggers can initiate a chronic disease such as rheumatism in one twin by an epigenetic process, while the DNA sequence remains constant. The main focus of the book has been on case studies of identical twins who were separated at birth and showed important differences.

[1] Allele is 'a shorthand form of allelomorph, one of a series of possible alternative forms of a given gene, differing in DNA sequence, and affecting the functioning of a single product (RNA and/or protein)' (King, R.: 2006, Allele, p. 15). Allele is 'an alternative form of a gene. For example, a hypothetical gene, C, could exist in three variant forms within a population — the alleles C, c and c1. Each allele represents a DNA sequence with slight differences from each other. A diploid organism carries two alleles for each gene locus, one on each homologous chromosome. The two alleles may be identical (e.g. genotype CC), or different (e.g. genotype Cc), and it is the particular combination of alleles that determines phenotype' (Lawrence, E.: 2005, Allele, p.22). Allele frequency is 'a measure of the commonness of an allele in a population, being the proportion of a given allele in the population with respect to all alleles of that gene' (Lawrence, E.: 2005, Allele frequency, p.22, 23).

[2] A gene pool is the complete set of alleles for a gene in a single population. Evolution occurs when there are changes in the frequencies of alleles within a population. (Wikipedia: Population genetics)

[3] The HGP was an international 13-year effort, 1990: 2003. Primary goals were to discover the complete set of human genes and make them accessible for further biological study, and determine the complete sequence of DNA bases in the human genome.

found in all members of one population and in no members of any other'(HGP: 2003). One crucial innovation in reconceptualizing genotypic and phenotypic variation was the anthropologist Charles Loring Brace's observation that such variations, insofar as it's affected by *natural selection*, *slow migration* or *genetic drift*, are distributed along geographic gradations or clines (Wikipedia: Race (human categorization)).

A cline describes 'a gradient of morphological or physiological change in a group of related organisms usually along a line of environmental or geographic transition' (Merriam-Webster: Cline). It describes a 'graded series of different forms of the same species, usually distributed along a spatial dimension' (Lawrence, E.: 2005, Cline, p.125). It's 'a gradient of phenotypic and/or gene frequency change along a geographical transect of the population's range' (King, R.: 2006, Cline, p. 87). Therefore, a cline arises when there are changes in the frequencies of gene expression within a population. Regarding humans, human clines consist of forms of humans who exhibit gradual phenotypic and/or genetic differences *over a geographical area* (Wikipedia: Cline (biology)).

A population that differs significantly from other populations regarding the frequency of one or more expressions of the genes it possesses (Boyd, W.: 1950, p. 207) – whether the reason is genetic or environmental or both – becomes distinct with one or more trait than the others – every population is characterized through its traits. Differences across human populations or groups in traits are one of many factors on which human categorization[1] depends.

On a statistical basis, it could be ensured that there are differences across populations in human traits. According to one of the reliable up-to-date statistical reports about human body measurements across populations (anthropometric data), the International Organization for Standardization (ISO) has provided (2010) updated country-specific body size data in its 2nd published report of ISO 7250[2] '*Statistical summaries of body measurements from individual ISO populations*' seeking to identify physical variations in human body sizes and

---

[1] Human categorization is a classification system used to categorize humans into large and distinct populations or groups by anatomical, cultural, ethnic, genetic, geographical, historical, linguistic, religious, and/or social affiliation. (Wikipedia: Race (human categorization))

[2] ISO 7250 is a series of reports on body measurements. It consists of the following parts, under the general title *Basic human body measurements for technological design*: Part 1: 2008, *Body measurement definitions and landmarks*; Part 2: 2010, *Statistical summaries of body measurements from individual ISO populations*; and Part 3: 2013, *Worldwide and regional design ranges for use in ISO products standards*.

shapes around the world. It focuses on working-age people within *ISO populations*[1] It features key statistics such as body mass (weight), stature (human height), eye height, chest depth, hip breadth, hand length, hand breadth, etc. For instance, the report tells us that while the average height and weight of an American man are respectively 1.76 m and 80 kg, and those of the average Thai man are 1.67 m and 64 kg; and while an average Dutch woman measures 1.67 m and weighs 72 kg, an average Japanese woman measures 1.57 m and weighs 51 kg (ISO 7250-2: 2010, pp. 18:23, 35: 50).

Human height is a clear example of the variety of human body measures across populations. It varies among individuals and greatly across populations (clinally)[2]. Gradual differences in height are obvious over many geographical areas. The average height of men in France, Spain, Belgium, Germany and the Netherlands is 1.756 m, 1.78 m, 1.786 m, 1.81 m and 1.838 m respectively; also, the average height of men in Indonesia, Vietnam, Cambodia, Malaysia and Thailand is 1.58 m, 1.621 m, 1.625 m, 1.663 m and 1.703 m respectively.[3 4]

Effects of cline (clinal affiliation) on the user's ability level of using the designed thing:

A. The clinal affiliation may affect the user's ability of using a designed thing via affecting *the user's body abilities related to using the designed thing* (the 1st concept). Clinal traits (distinct physical and physiological body measures) have an impact on their related body abilities in some way, thus, on the ability level of using related designed things and doing related tasks. With a clinal trait[5], an individual may record higher or lower body abilities levels in comparison to recorded levels of others belonging to different populations and having different traits while using the same designed thing. For example, considering dexterity, while Indonesian men tending to have small hands may face problems in catching and controlling the big handles of woodworking, farming and gardening tools, thus in completing related tasks as would have normally been expected, they may show higher levels of dexterity in using fine tools. On the contrary, Dutchmen tending to have big hands

---

[1] Countries whose national standards institute is a member of ISO – Austria, Germany, Italy, Japan, Kenya, Republic of Korea, the Netherlands, Thailand and the USA.

[2] They often differ significantly among populations and vary from country to country. Body proportions are known to vary among populations around the world.

[3] averageheight.co/ average-male-height

[4] The mentioned averages are representative of other studies whose results lie within the same averages.

[5] A clinal trait is a distinction in a human body measure resulting from the clinal affiliation.

may find difficulty in perfectly using fine tools; and they may show higher levels of dexterity in using tools with big handles[1]. From the previous, while a clinal trait of a man may affect negatively his ability of using some designed things (thus, doing their related tasks), it may affect positively his ability of using other designed things; the clinal trait doesn't have a negative or positive effect all the time but according to the nature of each designed thing or each task. In this, the clinal affiliation as a personal factor differs from some other personal factors (such as ageing and impairment) which often have negative effects on the body abilities levels (on the physical and physiological body measures), thus, on abilities levels of using related designed things.

B. The clinal affiliation may affect the user's ability of using a designed thing via affecting the 3rd concept '*the user's decisions toward using this thing*'. This can be attributed to the way an individual with a clinal trait (belonging to a specific cline) adapts to and copes with his/her clinal affiliation, and reflects it and all its accompanying matters on the use relation of this designed thing. Possible effects can be attributed to how the user with a clinal trait perceives the effects of his/her clinal affiliation on matters related to the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user firstly perceives the effects of his/her own clinal trait on his/her body abilities related to using the designed thing (the 1st concept), his/her ability of using this designed thing or similar designed things, his/her abilities of doing their related tasks, and his/her differences from others having different clinal traits regarding the body abilities level and abilities level of using this thing or doing its related tasks; and secondly reacts to them via actions regarding the *participation* and *adaptation*[2].

For instance, a man with a clinal trait may perceive it as an *activator* when it works as a *disadvantage* while using a designed thing and tries to adapt to this through modifying one or more of the use-related characteristics of this thing – incl. the normal method of using it, depending on assisting aids (incl. medical devices), or modifying one or more features of the performance environment when possible. In turn, these adapting actions would positively

---

[1] The physical constitution in Asians is on average generally thinner and shorter than in Westerners, and this tendency is also noticeable for the hands; East Asians tend to have narrower hands (lower hand index) (Martijn van Mensvoort). For confirming data about the average of Dutch hand measures, see (ISO 7250-2: 2010, pp. 35: 40).

[2] – see the footnotes in p. 74.

affect the 2 main pillars of use relation for this man and thus his ability of using this thing, and the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man with the same clinal trait may perceive it as a *deactivator* when it works as a *disadvantage* while using the same designed thing; and he may be compelled to ineffectively, unsatisfactorily or dependently use this thing – especially with the impossibility of implementing the previous adapting actions; or he may avoid using it, never use it again, or on the extreme side, avoid using similar designed things. In turn, this would negatively affect the buildup of his experience of using it and consequently his ability of using it. For example, an Indonesian man having small hands who faces problems in catching and controlling the big handle of a gardening tool may avoid using it, never use it again or avoid using similar ones. Actually, life is full of examples of people whose clinal traits working as disadvantages are motivators to do their best, and others whose clinal traits working as disadvantages are causes of frustration. On the other hand, a man with a clinal trait may perceive it as an *activator* when it works as an *advantage* while using a designed thing (a motivator for progress, distinction and superiority), which may positively affect his decisions toward using it, such as preferring to use it; which in turn, positively affects the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man with the same clinal trait may perceive it as a *deactivator* when it works as an *advantage* while using the same designed thing (a motivator for laziness, slouching, slack-ness or carelessness), which may have a negative effect on the buildup of his experience of using it and consequently his ability of using it.

The same could be argued regarding the way an individual with a clinal trait perceives and reacts to his/her differences (whether they are positive or negative values) from others having different clinal traits regarding the body abilities level and abilities level of using a designed thing or doing some tasks – as *activators* or *deactivators*.

Actually, perceiving and reacting to the effects of the clinal traits on matters related to the use relation are psychological matters, and they contribute to the beliefs of the individual being with a clinal trait about what he/she can and can't do, and what he/she can try to do and should avoid doing, which in turn form the required roles or responsibilities and expect-ations from him/her by others, or form some of the external attitudes[1] toward him/her by

[1] – see section 2.6.1.1, no. 5.

others**.** For instance, in a multinational community, an Indonesian man having small hands and who avoids using tools with big handles due to his small hand size (a clinal trait) or his sureness that the others having normal and big hands (with different clinal traits) have a preference while using these tools, contributes to the stereotypes about him by others regarding using these things and similar ones; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to him.

In addition to distinct body measures of people belonging to a specific cline and their accompanying psychological and behavioural issues affecting negatively or positively their abilities of using things and doing tasks, these people also face other social issues, such as negative or positive attitudes toward them because of their abilities, looks and behaviour – their clinal affiliation. Such social issues mostly are results of the distinct levels of body abilities and their accompanying psychological and behavioural issues of people belonging to this cline. Actually, clinal affiliation is a multidimensional domain of biological, psychological and social matters.

To conclude, the *clinal affiliation* plays a significant role in what level of abilities of using designed things and doing tasks an individual has (in affecting people's abilities levels of using designed things), and it's a main personal factor of the *human diversity*. For actors, users aren't only the people belonging to one cline; now, in our globalized world, most societies consist of individuals who belong to many clines (with different clinal traits) and most designed things move across borders.

5. Abnormality of human body measures:

Globally and clinally, the majority of able-bodied humans belonging to the same age phase[1] and sex[2] fall under common ranges of human physical and physiological body measures, thus, are within common ranges of body abilities levels. The minority, who don't conform to these ranges – with exceptional body measures – appear to be abnormal due to this deviation from humans' or a population's common ranges. Very short, tall, fat, thin, huge, long-arms and short-arms people; teeny-handed, huge-handed adults; left-handed people and others are examples of those people who aren't often within the common ranges of such measures.

There's significant variation in human physical and physiological body measures among people; e.g. globally, the human adult's height (stature) varies greatly among individuals (Wikipedia: Anthropometry). According to the documented examples of adults' height, for men, height has ranged from 0.546: 2.72 m – from the Nepali Chandra Bahadur Dangi to the American Robert Pershing Wadlow respectively; for women, height has ranged from 0.584: 2.48 m – from the Dutch Pauline Musters to the Chinese Zeng Jinlian respectively (Guinness World Records). *Globally*, while the estimated average height for the human adult male and female across the world is approximately 1.73 m and 1.60 m respectively[3], men above 1.95 m and under 1.50 m and women above 1.85 m and under 1.40 m appear to be abnormal in terms of height. *Clinally*, with the average height of the Dutch adult male (20+) at 1.808 m (StatLine: Reported height), while 89.8% ranging from 1.68 to 1.92 m (ibid.) appear to be normal, 0.6% under 1.63 m and 2% above 1.97 m (Ibid.) appear to be abnormal; and with the average height of the Dutch adult female (20+) at 1.675 m (StatLine: Reported height and ISO 7250-2: 2010, p. 35: 40), while 90.4% ranging from 1.58 to 1.82 m (StatLine: Reported height) appear to be normal, 2.1% under 1.53 m and 0.2% above 1.88 m (ibid.) appear to be abnormal. Also, with the average height of the Indonesian adult male at 1.58 m[4], a 1.8 m Indonesian man appears to be abnormal; and with the average height of the Indonesian adult female at 1.47 m[5], a 1.70 m Indonesian woman appears to be abnormal.[6]

[1] Age phases are infancy, childhood, adolescence, adulthood and ageing/late adulthood.

[2] Human sex is a male, a female or an intersex.

[3] averageheight.co/average-male-height and averageheight.co/average-female-height

[4] averageheight.co /average-male-height-by-country

[5] averageheight.co/average-female-height-by-country

[6] The mentioned averages are representative of other studies whose results lie within the same averages.

Also, regarding the human adult's weight, globally, human weight varies extensively among individuals (Wikipedia: Anthropometry). According to the documented examples of adults' weight, it has ranged from the Mexican Lucia Zarate who weighed 2.13 kg (Wikipedia: Lucia Zarate) to the American Jon Brower Minnoch who weighed 635 kg (Guinness World Records). *Globally*, the estimated average body mass was 62 kg in 2005 (Walpole, S.: 2012, p. 442), thus adults above 100 kg and under 45 kg appear to be abnormal in terms of weight. In 2014, globally, more than 1.9 billion adults, 18 and older, were overweight; over 600 million of these adults were obese (WHO: 2014, Obesity and overweight). In 2014, 41 million children under the age of 5 were overweight or obese (ibid.). *Clinally*, with the average weight of the Dutch adult male (20+) at 83.8 kg (StatLine: 2014, *Reported weight*), while 78.6% ranging from 68 to 97 kg (ibid.) appear to be normal, 3.1% under 63 kg and 13.3% above 97 kg (ibid.) appear to be abnormal in terms of weight; and with the average weight of the Dutch adult female (20+) at 70.3 kg (ibid.), while 85.8% ranging from 58 to 87 kg (ibid.) appear to be normal, 1% under 48 kg and 5.8 % above 93 kg (ibid.) appear to be abnormal. According to StatLine[1], in the Netherlands 2013, 1.8% of males (4+) and 3.2% of females (4+) are under-weight and 9.1% of males (4+) and 11.1% of females (4+) are seriously overweight (StatLine: Under- and overweight).

With regards to left-handers (lefties), *worldwide*, left-handedness[2] is less common than right -handedness (Hardyck, C.: 1977); statistics suggest that approx. 13% of the world population is left-handed[3]. *Clinally*, an estimate for left-handedness in the Western world (roughly North America and Western Europe) is around 12%; within the 12% of North Americans who claim left-handedness, men are slightly more likely than women to be left-handed, with most studies indicating that about 13% of men and just under 11% of women are left-handed[4].

The previous examples have clarified that there are remarkable proportions of people not lying within the common range of the human body measures on the global and clinal level. These people aren't characterized as ill, impaired or even superior, but as abnormal due to their distinct human body measures.

[1] StatLine is the electronic databank of Statistics Netherlands.

[2] Left-handed people are more skillful with their left hands when performing tasks.

[3] statisticbrain.com/left-handed-statistics/

[4] rightleftrightwrong.com /statistics.html

Effects of abnormal body measures on the user's ability level of using the designed thing:

A. The abnormal body measures may affect the user's ability of using a designed thing via affecting *the user's body abilities related to using the designed thing* (the 1st concept). The abnormality of a human body measure has an impact on its related body ability in some way, thus, on the ability level of using related designed things and doing related tasks. An individual with an abnormal physical[1] or physiological body measure, may record higher or lower body abilities levels in comparison to recorded levels of the majority being within the common range while using the same designed thing. For example, considering dexterity, while teeny-handed men may face many problems in catching and controlling the big handles of woodworking, farming and gardening tools, thus in completing related tasks as would have normally been expected, they may show higher levels of dexterity in using fine tools, keys of small mobile phones, touch screens of small handheld computing tools or small laptops keyboards. On the contrary, huge-handed men may find difficulty in perfectly using fine tools; and they may show higher levels of dexterity in using tools with big handles. From the previous, while the abnormality of the hand size of a man affects negatively his ability of using some designed things (thus, doing their related tasks), it affects positively his ability of using other designed things; the abnormality doesn't have a negative or positive effect all the time but according to the nature of each designed thing and each task. That's to say, the abnormality of human body measures as a personal factor differs from some other personal factors (such as ageing and impairment) often having negative effects on the body abilities levels (on the physical and physiological body measures), thus, on abilities levels of using related designed things.

B. The abnormality of human body measures may affect the user's ability of using a designed thing via affecting the 3rd concept '*the user's decisions toward using this thing*'. This can be attributed to the way an individual with an abnormal body measure adapts to and copes with his/her abnormal body measure, and reflects it and all its accompanying matters on the use relation of this designed thing. Possible effects can be attributed to how the user with an abnormal body measure perceives the effects of his/her abnormality on matters related to the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user firstly perceives the effects of abnormality on his/her body abilities related to

[1] – macroscopic or microscopic anatomical measures

using the designed thing (the 1st concept), his/her ability of using this designed thing or similar designed things, his/her abilities of doing their related tasks, and his/her differences from the majority (being with the normal measure) regarding the body abilities level and abilities level of using this thing or doing its related tasks; and secondly reacts to them through actions regarding the *participation* and *adaptation*[1].

For instance, a man with an abnormal body measure may perceive his abnormality working as a *disadvantage* while using a designed thing as an *activator* and try to adapt to this through modifying one or more of the use-related characteristics of this thing – incl. the normal method of using it, depending on assisting aids (incl. medical devices), or modifying one or more features of the performance environment when possible. In turn, these adapting actions would positively affect the 2 main pillars of use relation for this man and thus his ability of using this thing, and the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man with the same abnormal body measure may perceive his abnormality working as a *disadvantage* while using a designed thing as a *deactivator*; and he may be compelled to ineffectively, unsatisfactorily or dependently use this thing – especially with the impossibility of implementing the previous adapting actions; or he may avoid using it, never use it again, or on the extreme side, avoid using similar designed things. In turn, this would negatively affect the buildup of his experience of using it and consequently his ability of using it. For example, a huge-handed man who finds difficulty in perfectly using the keys of a small mobile phone may avoid using it, never use it again, or avoid using all small mobile phones. Actually, life is full of examples of people with abnormal body measures, whose abnormalities working as disadvantages are motivators to do their best, and others whose abnormalities working as disadvantages are causes of frustration. On the other hand, a man with an abnormal body measure may perceive his abnormality working as an *advantage* while using a designed thing as an *activator* (a motivator for progress, distinction and superiority), which may positively affect his decisions toward using it, such as preferring to use it; which in turn, positively affects the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man with the same abnormal body measure may perceive his abnormality working as an *advantage* while using a designed thing as a *deactivator* (a motivator for laziness, slouching,

[1] – see the footnotes in p. 74.

slackness or carelessness), which may have a negative effect on the buildup of his experience of using it and consequently his ability of using it.

The same could be argued regarding the way an individual with an abnormal body measure perceives and reacts to his/her differences (whether they are positive or negative values) from the majority (being with the normal measure) regarding the body abilities level and abilities level of using a designed thing or doing some tasks – as *activators* or *deactivators*.

Actually, perceiving and reacting to the effects of the abnormality of body measures on matters related to the use relation are psychological matters, and they contribute to the beliefs of the abnormal individual about what he/she can and can't do, and what he/she can try to do and should avoid doing, which in turn form the required roles or responsibilities and expectations from him/her by others, or form some of the external attitudes[1] toward him/her by others. For example, a huge-handed man who avoids using manual fine tools[2] due to his big hand size (abnormal body measure) or his sureness that the majority having small or normal hands size have a preference while using these tools, contributes to the stereotypes about him by others regarding using these things and similar ones; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to him.

In addition to the abnormality of body measures and their accompanying psychological and behavioural issues affecting negatively or positively the abilities of using things and doing tasks, people with abnormal body measures also face other social issues, such as negative or positive attitudes toward people with abnormal body measures because of their abilities, looks and behaviour[3]. Such social issues mostly are results of the abnormal levels of body abilities and their accompanying psychological and behavioural issues of abnormal people. Actually, abnormality of the human body measures is a multidimensional domain of biological, psychological and social matters.

---

[1] – see section 2.6.1.1, no. 5.

[2] – requiring small or normal hand size to be perfectly used.

[3] For example, considering the adult height, some jobs do require or at least favour tall people, incl. some manual labour jobs, law enforcement, most professional sports, flight attendants, and fashion modelling (Wikipedia: Height discrimination). Surveys have uncovered that less than 3% of chief executive officers (CEOs) were below 1.70 m in height. 90% of CEOs are of above-average height (Rauch, J.: 1995).

To conclude, the *abnormality of human body measures* plays a significant role in what level of abilities of using designed things and doing tasks an able-bodied individual has (in affecting people's abilities levels of using designed things), and it's a main personal factor of the *human diversity*. For actors, people with abnormal body measures are around us everywhere – anyone may have one or more abnormal body measures, and users aren't only people being within the common ranges or around the averages of the human physical and functional body measures. Depending on the averages is misleading because it unintentionally excludes people with abnormal body measures although they are considered when the averages are calculated. Even if they are small proportions, in big groups of people, small proportions make up a large number of people that can't be underestimated.

6. Other personal factors *directly* related to the use relation:

The debate regarding the effects of nutrition and fitness (as personal factors closely related to the use relation) on the user's ability of using the designed thing is via discussing their effects on the user's body abilities related to using the designed thing (the 1st concept) and the user's decisions toward using this thing (the 3rd concept).

Also, the debate regarding the effects of knowledge, education and profession[1] (as personal factors closely related to the use relation) on the user's ability of using the designed thing is via discussing their effects on the user's cognitive abilities related to using the designed thing (the 1st concept) and the user's decisions toward using this thing (the 3rd concept).

Both debates are similar to the aforementioned debates on ageing, impairment, sex, clinal affiliation and abnormality of body measures.

[1] – knowledge, education and profession from the perspective of their effects on the cognitive ability and skill level.

7. Skill level – Prior experience:

Skill is the ability to use one's knowledge effectively and readily in execution or performance (Merriam Webster: Skill). It comes from training, experience or practice. Experience is the practical knowledge, skill or practice derived from direct observation of or participation[1] in events or a particular activity (Merriam Webster: Experience). The experience level of using a newly launched designed thing is based on the prior experience of using similar things or previous versions of this thing. Actually, the individual's experience level of using a designed thing or doing a task is the result of his/her compiled experiencing ability affected by the personal and environmental factors relating to: usability such as ageing, impairment, sex, clinal affiliation and abnormality of human body measures; harmonizability such as cultural values; and accessibility such as economic status. For example, the individual's economic status may affect his/her computer access which in turn affects his/her skill level in using computers. Skill level differences among people in using the same designed thing are often related to differences in these factors to make for a complex variable (Ashok, M.: 2009, p. 4-6). For example, 'inequality in economic status causes inequality in computer access, which in turn causes inequality in computer skill level. This chain of events could lead to a situation where two children of the same age have different levels of comfort using the same word processing tool, because of differences in their home environments' (ibid.).

Effects of skill level on the user's ability level of using the designed thing:

A. The experience level may affect the user's ability of using a designed thing via affecting *metaphorically* the *user's body abilities related to using the designed thing* (the 1st concept). The experience level of using a designed thing has an impact on the use efficiency of body abilities related to using it while using it, thus, on the ability level of using it and doing its related tasks. A man may *metaphorically* record higher or lower body abilities levels than his realistic/existing levels while using a particular designed thing according to his experience level of using it. For example, considering cognition (a body ability), while using a new version of a touch screen mobile phone for the first time and without having prior experience in using this technology, the user behaves like a novice and it appears as if he has lower levels of cognition; and while using this new version and with having prior experience in using this technology through using older versions or similar mobile phones, the user behaves like an

[1] Experience is the skill or knowledge that you get by doing something.

expert[1] and it appears as if he has higher levels of cognition. The same could be argued regarding the low experience level of an old woman while setting up a digital TV or a mobile phone, and an adult man used to buy tickets from ticket offices and doesn't know how to use the automated ticket machines.

By using another thing or doing another task depending on the same body abilities, a different spectrum of differences in the level of use efficiency of these body abilities of the same individual are formed according to the experience level he/she has. For example, considering dexterity, an able-bodied man who practices tennis and has never practiced squash, appears as if he has higher levels of dexterity while using a tennis racket and lower levels of dexterity while using a squash racket. So, judging the skill levels of people can be more difficult than assessing impairments or difficulties because people who are experts in using a particular a designed thing or doing a particular task may find a new designed thing hard to use or a new task hard to do – this results in a situation where a person who you may think is an expert actually behaves like a novice (Ashok, M.: 2009, p. 4-6). In other words, the level of use efficiency of the user's body abilities for using different designed things – thus his/her ability of using them – varies according to the user's prior experiences of using them.

Regarding different levels of experience of using a designed thing among people, while an old man with a low dexterity level and a high prior experience level in using a drilling machine shows a high-performance level in using it, an able-bodied young adult man with a high level of dexterity and a low prior experience in using this machine shows a low-performance level in using it. Here, prior experience has made the adult man behaves as having a low dexterity level, and the old man behaves as having a high dexterity level. Also, while most children aged less than 12 years use technology in routine activities such as information searching, reading, writing and entertainment, still there are adult people – particularly older people[2], unfamiliar with technology; although older people have higher cognitive abilities levels than the children, they appear as having lower levels while using IT products due to differences

[1] – i.e. experienced, skilled, proficient or practiced

[2] With the pervasiveness of technology today, many routine activities are now performed electronically. Shopping, banking, information searching, reading, writing and entertainment are now performed easily with personal computers, handheld devices and even mobile phones (Ashok, M.: 2009, p. 4-6). Older people, who didn't grow up surrounded by information technology (IT), may not feel as comfortable with IT products as younger people do (Jordan, P.: 1999, p. 175).

between them in the experience level of using IT products; here, the prior experience has made adult people behave like novices, and children behave like experts.

The previous shows how the prior experience of using a specific designed thing affects the use efficiency of body abilities related to using it while using it, thus, the ability level of using it.

B. Prior experience may affect the user's ability of using a designed thing via affecting the 3rd concept '*the user's decisions toward using this thing*'. This can be attributed to the way an individual with a specific experience level regarding the use of a designed thing adapts to and copes with his/her experience level, and reflects it and all its accompanying matters on the use relation of this designed thing. Possible effects can be attributed to how the user with a specific experience level perceives the effects of his/her experience level on matters related to the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user firstly perceives the effects of experience level on the use efficiency of his/her body abilities related to using the designed thing, his/her ability of using this designed thing or similar designed things, his/her abilities of doing their related tasks, and his/her differences from the others (being with different experience levels) regarding the abilities level of using this thing or doing its related tasks; and secondly reacts to them through actions regarding the *participation* and *adaptation*[1]. Skill level plays a role in the attitude users have toward using and accepting new or unfamiliar designed things for them (Ashok, M.: 2009, p. 4-6).

For instance, a man with a low experience level regarding the use of a designed thing or similar things may perceive this level working as a *disadvantage* while using this designed thing as an *activator* and may try to adapt to this through modifying one or more of the use -related characteristics of this thing – incl. the normal method of using it, relying on assisting aids (incl. medical devices), or modifying one or more features of the performance environment when possible. In turn, these adapting actions would positively affect the 2 main pillars of use relation for this man and thus his ability of using this thing, and the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man with a low experience level regarding the use of the same designed thing or similar things may perceive this level working as a *disadvantage* while using this designed thing as a

[1] – see the footnotes in p. 74.

deactivator; and he may be compelled to ineffectively, unsatisfactorily or dependently use this thing – especially with the impossibility of implementing the previous adapting actions; or he may avoid using it, never use it again, or on the extreme side, avoid using similar designed things. In turn, this would negatively affect the buildup of his experience of using it and consequently his ability of using it. For example, those who are unfamiliar with using the Internet might resist a web-based service to replace their daily banking chores (Ashok, M.: 2009, p. 4-6). It's an emotional situation that may create resistance to technology[1] (ibid.: p. 4-11). On the other hand, a man with a high experience level regarding the use of a designed thing or similar things may perceive this level working as an *advantage* while using this designed thing as an *activator* (a motivator for progress, distinction and superiority), which may positively affect his decisions toward using it, such as preferring to use it; which in turn, positively affects the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man with a high experience level regarding the use of the same designed thing or similar things may perceive this level working as an *advantage* while using this designed thing as a *deactivator* (a motivator for laziness, slouching, slackness or carelessness), which may have a negative effect on the buildup of his experience of using it and consequently his ability of using it.

The same could be argued regarding the way an individual with a specific experience level regarding the use of a designed thing or similar things perceives and reacts to his/her differences (whether they are positive or negative values) from the others (being with different experience levels) regarding the abilities level of using this designed thing or doing its related tasks – as *activators* or *deactivators*.

Actually, perceiving and reacting to the effects of the personal experience level of using a designed thing on matters related to the use relation are psychological matters, and they contribute to the beliefs of the individual about what he/she can and can't do, and what he/ she can try to do and should avoid doing, which in turn form the required roles or responsibilities and expectations from him/her by others, or form some of the external attitudes[2]

[1] Also, the elderly 'may feel a sense of resistance to certain technologies, especially when dealing with applications for tasks that people are used to completing without technology, such as online banking systems' (Ashok, M.: 2009, p. 4-11). Now, many older users are unable to manage the emerging multitude of technological innovations (ibid.).

[2] – see section 2.6.1.1, no. 5.

toward him/her by others. For instance, an old man who avoids using IT products – due to his nihilistic experience of using them or his sureness that others having enough experience in using them have the preference while using these products – contributes to the stereotypes about him by others regarding using these things and similar ones; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to him.

In addition to prior experience and its accompanying psychological and behavioural issues affecting negatively or positively the abilities of using things and doing tasks, novice and skilled people also face other social issues, such as negative or positive attitudes toward people with low and high experience levels respectively.

To conclude, *prior experience* of using a designed thing, similar things or related matters plays a significant role in what level of abilities of using this thing and doing its related tasks an individual has (in affecting people's abilities levels of using this thing), and it's a main personal factor of the *human dynamic diversity*, it creates a great source of diversity among people. The level of comfort and the ease of using a designed thing or doing its related tasks or actions vary significantly depending on the prior experience level of the users (Ashok, M.: 2009, p. 4-6). For actors, users fall within a wide and uneven spectrum of skills (ibid.), and they aren't only skilled people.

2.5.1.2: Effects of the personal factors *indirectly* related to the use relation:

Personal factors *indirectly* related to the use relation are personal factors that don't affect the 1st concept '*the user's body abilities related to using the designed thing*' on their way to affect the individual's ability of using designed things. They include income and wealth, social status, political power, geographical location, knowledge, education, profession[1], cultural identity and character style. Actually, features of these personal factors make up the individual's empowerment- and ideology-related characteristics. Actually, as it's clarified for example in section 3 regarding the access relation, these personal factors *directly* affect the individual's ability of accessing to or harmonizing with the designed thing (affect the user -designed thing relations of access or harmony). *Indirectly*, these factors may have effects on the user's ability of using a designed thing via their effects on the user-designed thing relations of access or harmony. This is via affecting the 3rd concept '*the user's decisions toward using this thing*'. Possible effects can be attributed to how the user perceives the effects of a personal factor on the access or harmony relation – as *activators* or *deactivators*, and reacts to them in regards to using this thing. The user perceives the negative or positive effects of a personal factor on his/her ability of accessing to or harmonizing with this designed thing; and reacts to them via actions regarding the *participation* and *adaptation*.

Participation affects the occurrence and activation of the use interaction, and with the recurrence of participation, it affects the buildup of the user's experience of using this thing, which in turn affects his/her ability of using it. *Adaptation* through modifying the designed thing characteristics related to use (incl. the normal method of use) – the 2nd concept – for improving the ability of access or harmony, affects the 2nd pillar of the use relation '*current demands of using the designed thing*' and thus the quality of use interaction.

For instance, a man who hasn't the affordability to access an expensive printer ink cartridge – negative effect of his income or wealth (*empowerment*-related personal factors), a man who has the financial ability to access it but he isn't in harmony with it because of its price – negative effect of his ideologies or norms (character style – an *ideology*-related personal factor) in regards to the maximum amount of money he is willing to pay, an Arabian who doesn't harmonize with laptops as their keyboards don't offer the Arabic symbols – negative effect of his commonly used language (cultural identity – an *ideology*-related personal

[1] – knowledge, education and profession from the perspective of their effects on the person's empowerment.

factor), or a Muslim who doesn't harmonize with a designed thing having a slogan looking like a cross – negative effect of his beliefs (cultural identity – an *ideology*-related personal factor)[1] – may perceive this negative effect of his features of the mentioned personal factor as an *activator* and try to adapt to this through modifying one or more of the use-related characteristics of this thing (when possible) for easier access or better harmony. The first man may manually refill the ink cartridge to save money, but it may not be as easy as usual while replacing a new original cartridge; the Arabian may stick Arabic symbols beside the existing symbols on the laptop keys which could negatively affect both speed and accuracy of typing as a result of possible distraction from close by symbols; and the Muslim may remove or cover the slogan which may make it less easy while using the attendant thing. Actually, these modifications in the use-related characteristics of the aforementioned things may improve – positively affect – the previous individuals' abilities of accessing to or harmonizing with these things, but on the other side, such modifications may negatively affect their abilities of using these things in some way and the buildup of their experience of using these things and consequently their abilities of using them. Conversely, the aforementioned individuals may perceive the negative effect of their features of personal factors on the access or harmony relation as *deactivators*; and they may be compelled to inefficiently, unsatisfactorily or inharmoniously use these things (the 2nd, 3rd, 4th example) – especially with the impossibility of implementing the previous adapting actions; or they may avoid accessing or using them (the 4 previous examples), never access or use them again, or on the extreme side, avoid accessing or using similar designed things. In turn, this would negatively affect the buildup of their experience of using these things and consequently their abilities of using them.

On the other hand, a man whose features of a personal factor related to empowerment or ideology have positive effects on his abilities of accessing to or harmonizing with a designed thing respectively may perceive these positive effects as an *activator* (a motivator for progress, distinction and superiority), which may positively affect his decisions toward using it, such as preferring to use it; which in turn, positively affects the buildup of his experience of using it and consequently his ability of using it. On the contrary, the same man may perceive these positive effects as a *deactivator* (a motivator for laziness, slouching, slackness or

[1] Another example is an individual not being in harmony with a designed thing because it's designed without considering the environmental impact in one of its life cycle phases – a negative effect of the individual's values or norms (character style – an *ideology*-related personal factor).

carelessness), which may have a negative effect on the buildup of his experience of using this thing and consequently his ability of using it.

The same could be argued regarding the way an individual perceives and reacts to his/her differences (whether they are positive or negative values) from the other people regarding the features of personal factors related to empowerment and ideology, and the abilities level of accessing to or harmonizing with a designed thing – as *activators* or *deactivators*.

Actually, perceiving and reacting to effects of personal factors *indirectly* related to the use relation on matters related to the use relation are psychological matters, and they contribute to the beliefs of the individual about what he/she can do and can't, and can try to do and should avoid, which in turn form the required roles or responsibilities and expectations from him/her by others, or form some of the external attitudes[1] toward him/her by others. For instance, the aforementioned Arabian who avoids using laptops as their keyboards don't offer the Arabic symbols, or due to his sureness that the others harmonizing with them have the preference while using laptops in writing Arabic, contributes to the stereotypes about him by others regarding using laptops and similar things; in turn, this forms the expectations about the roles and responsibilities that may be given or allowed to him.

In addition to empowerment- and ideology-related characteristics and their accompanying psychological and behavioural issues affecting negatively or positively the abilities of using things and consequently doing tasks, people with these characteristics also face other social issues, such as negative or positive attitudes toward people with these characteristics due to these characteristics, their abilities level of access or harmony and their behaviours related to these characteristics. Actually, each personal factor *indirectly* related to the use relation is a multidimensional domain of psychological and social matters.

To conclude, the *empowerment- and ideology-related personal factors* play a significant role in what level of abilities of using designed things and doing tasks an individual has (in affecting people's abilities levels of using designed things), and they are main personal factors of the *human diversity*. For actors, not only personal factors related to body or skill affect the individual's ability of using designed things but also personal factors related to empowerment or ideology.

[1] – see section 2.6.1.2, no. 2.

2.5.2. Dynamism – Changeability of the user's characteristics – Effect of time change:

As is mentioned before, the user as a human is an integrated context of the numerous personal factors whose current features (absence, presence, values and/or qualities) make up his/her corresponding characteristics related to body[1], skill, empowerment and ideology which in turn make up his/her psychological and attitudinal characteristics. Due to the reason that features of most personal factors are *changeable with time* – such as those being of age, temporary and permanent impairments, nutrition, fitness, knowledge, education and profession, skill level, income and wealth, political power, social status, geographical location, cultural identity and character style; some characteristics of a user may change. Changes may happen slowly or quickly, regularly or irregularly, and may range from minor to radical. Actually, changeability of the characteristics (*dynamism*) of a user readily takes place; thus, the user is considered *a dynamic unit*. Hereby, on an individual's level, changes in a user's characteristics may have a different impact (may be dramatic) on his/her performance while using the same designed thing even if in the same environment. For example, as has been mentioned before[2], changes in the biological, psychological and attitudinal characteristics resulting from ageing or permanent impairments affect in some way elders' and impaired people's abilities level of using related designed things and completing related tasks as compared to those levels before the ageing phase and impairments.

2.5.3. Variety and plurality of the potential users:

Each user as a human has his/her own characteristics related to body, skill, empowerment, ideology, psychology and attitude characteristics, resulting from the current features (absence, presence, values and/or qualities) of the numerous personal factors. These characteristics *distinguish* users from each other and express the extent of differences among them. Differences in these characteristics among users may range from very low to very high according to differences in their own features of the same personal factors. In turn, differences in such characteristics among users may lead to corresponding differences in their abilities levels of using related designed things or completing related tasks. *Diversity* of the users – being already *dynamic units* – regarding such characteristics is an indisputable fact.

[1] Body-related characteristics are biological (physical and physiological) characteristics.

[2] See sections, Ageing and Impairment.

Dynamic diversity of the users in such characteristics is an essential aspect that must be considered while designed things are created.

Due to the reason that *most* designed things are created not to be used by (aren't custom made for) a specific person or a group whether in a specific performance environment or different environments[1], *plurality/plenty* of users – being already *diverse* and dynamic – who may use a designed thing or copies of it, readily takes place; just, take a look inside a house, plane, workplace, factory or public place, or a look at the different people waiting for the new version of Apple smartphone in front of stores around the world.

[1] In a world where most designed things have moved across borders, there's a sheer increase in the number of diverse performance environments in which a copy of a designed thing may be used. Nowadays, countless copies of a designed thing are being used by different users in different performance environments.

2.5.4. Conclusion:

To conclude the former debate regarding the user, it could be briefly stated that:

1. The *personal factors* play a significant role in affecting the user's ability level of using a designed thing and doing its related tasks, through affecting one or more of the following 3 concepts: *the user's body abilities related to using the designed thing*, the designed thing characteristics related to use and *the user's decisions toward using the designed thing*. The personal factors can enhance or hamper the *user's experience*. This reflects the importance of the personal factors in the wider context of *user-designed thing interaction*.
2. Not only the personal factors *directly* related to the use relation (personal factors related to body or skill) affect the user's ability of using the designed thing, but also personal factors *indirectly* related to the use relation (personal factors related to empowerment or ideology – *directly* related to the access or harmony relations) – table 2.3.
3. The effects of the personal factors on the *aforementioned 3 concepts* result in some considerable aspects – table 2.3. These aspects are represented in:

- *The own biological state of the user's body systems related to using the designed thing*. It's concerned with to what extent his/her related body systems function well. It's based on the physical/anatomical and physiological measures of these systems and reflects the effects of personal factors directly related to the use relation on these systems – personal factors related to body or skill (metaphorically). *Aspect Nr. 1*
- *The user's decisions toward using the designed thing induced by personal factors directly related to the use relation* (body- or skill-related personal factors) due to their effects on the use relation[1] or due to other matters related to these effects (matters considered by the user such as differences from the other). These decisions reflect the user's current psychological state toward both: 1- the effects of these factors on his/her body abilities (even if *metaphorically*[2]) related to using the designed thing (the 1st concept), and on his/her ability of using this designed thing; 2- differences from the other. These decisions are materialized

[1] – through their role in forming the *aspect Nr. 1* of the use relation, thus in interaction competence of it.

[2] – when the personal factor is *skill level*.

through the user's actions regarding his/her *participation* and *adaptation*[1] which form his/her engagement state in using this thing. *Aspect Nr. 6*

- *The user's decisions toward using the designed thing induced by personal factors directly related to the access or harmony relations* (indirectly related to the use relation – personal factors related to empowerment or ideology respectively) due to their effects on the access or harmony relations respectively or due to other matters related to these effects (matters considered by the user such as differences from the other). These decisions reflect the user's current psychological state toward both: 1- the effects of empowerment- or ideology-related personal factors on his/her empowerment- or ideology-related characteristics related to accessing to or harmonizing with the designed thing respectively, and on his/her ability of accessing to or harmonizing with this designed thing respectively; 2- differences from the other. These decisions are materialized through the user's actions regarding his/her *participation* and *adaptation*[2] which form his/her engagement state in using this thing. *Aspect Nr. 8*
- *The assisting aids-induced biological state of the user's body systems related to using the designed thing*, being a user's reaction to (a form of adaptation to) the personal factors *directly* related to the use relation (personal factors related to body or skill) due to their effects on this relation or due to other matters related to these effects (matters considered by the user such as differences from the other) – see *aspect Nr. 6*. It's concerned with temporary and permanent changes that may occur in the own biological state of the user's body systems related to using the designed thing by the user through depending on assisting aids (incl. medical devices). *Aspect Nr. 3.1*
- *The user-induced state of the designed thing characteristics related to use*, being a user's reaction to (a form of adaptation to) the personal factors related to body, skill, empowerment or ideology (all personal factors directly or indirectly related to the use relation) due to their effects on the relations of use, access or harmony respectively or due to other matters

[1] *Adaptation* via modifying the designed thing characteristics related to use (incl. the normal method of use) – the 2nd concept, or modifying the user's body abilities related to using the designed thing (the 1st concept) via depending on assisting aids (incl. medical devices), affects the 2 main pillars of the use relation and thus the quality of usage interaction; adaptation aims to improve the ease of using the designed thing.

[2] *Adaptation* via modifying the designed thing characteristics related to use (incl. the normal method of use) (the 2nd concept), affects the 2nd pillar of the use relation (current demands of using the designed thing) and thus the quality of usage interaction. Adaptation aims to improve the ability of access to or harmony with the designed thing.

related to these effects (matters considered by the user such as differences from the other). It's concerned with temporary and permanent changes that may occur in the original use -related characteristics of the designed thing (incl. the method of use) by the user as a reaction to the personal factors directly or indirectly related to the use relation – see *aspects Nr. 6 and 8*. *Aspect Nr. 5.1*

4. The user is *a dynamic unit*. Features (absence, presence, values and/or qualities) of most personal factors making up the characteristics of a user are *changeable with time*. In turn, changes in related characteristics may differently impact the user's performance of using a particular designed thing even if in the same environment.

5. According to the own features of the numerous personal factors, users are *diverse* in their characteristics related to body, skill, empowerment and ideology, thus, related to psychology and attitude. In turn, differences in these characteristics among users may lead to corresponding differences in their abilities levels of using related designed things or completing related tasks. The level of comfort and the ease of using a designed thing or doing its related tasks or actions vary significantly depending on the own aforementioned characteristics of the users. Also, the *plurality* of users – being already *diverse* and *dynamic* – who may use a designed thing or copies of it, is a permanent occurrence. The *dynamic diversity* of users in these characteristics is an essential aspect that must be considered while designed things are created, and the *plurality* of the possible users makes it more essential and challenging.

Dynamism - Changeability of the user's characteristics

Variety of the potential users

Concepts / Personal factors		The user's body abilities related to using the designed thing	The designed thing characteristics related to use	The user's decisions toward using the designed thing
Personal factors *directly* related to the use relation – (Personal factors related to body or skill)	Ageing	✓ Aspect 1		✓ Aspect 6
	Impairment	✓ Aspect 1		✓ Aspect 6
	Sex	✓ Aspect 1		✓ Aspect 6
	Clinal affiliation - race	✓ Aspect 1		✓ Aspect 6
	Abnormality of body measures	✓ Aspect 1		✓ Aspect 6
	Nutrition	✓ Aspect 1		✓ Aspect 6
	Fitness	✓ Aspect 1		✓ Aspect 6
	Knowledge	✓ Aspect 1		✓ Aspect 6
	Education and Profession	✓ Aspect 1		✓ Aspect 6
	Prior experience (skill level)	metaphorically ✓ Aspect 1		✓ Aspect 6
Personal factors *indirectly* related to the use relation (Personal factors directly related to the access or harmony relations – to empowerment or ideology)	Income and Wealth			✓ Aspect 8
	Political Power			✓ Aspect 8
	Social status			✓ Aspect 8
	Geographical location			✓ Aspect 8
	Knowledge			✓ Aspect 8
	Education			✓ Aspect 8
	Profession			✓ Aspect 8
	Cultural identity			✓ Aspect 8
	Character style			✓ Aspect 8
	Others			✓ Aspect 8
		✓ Aspect 3. 1	✓ Aspect 5. 1	

Adaption

Adaption

Participation

Interaction

Table 2.3: It shows the different aspects resulting from the effects of the personal factors on the 3 main concepts, thus on the user's ability of using a designed thing. Also, it points out the *changeability* of these effects according to the *changeability* of the user's characteristics with time (*dynamism*), and the *variety* of potential users who may use a designed thing or copies of it.

2.6. The performance environment – The environmental factors:

A performance environment of a designed thing is a medium in which this thing is actually used – a user bodily interacts with this thing. Like all environments, it's an integrated context of the numerous environmental factors whose current features (absence, presence, values and/or qualities) make up its corresponding *physical*, *social* and *attitudinal* characteristics. Environmental factors[1] refer to all aspects of the external or extrinsic world that partly[2] form the context of an individual's life and, as such, have an impact on that person's functioning (WHO: 2001, p. 213). Here, the environmental factors represent the external influences on the individual's ability level of using designed things – the impact of attributes of the performance environment. As will be discussed in section 2.6.1 below, such factors can have a positive or negative impact on one or more of the *3 aforementioned concepts*[3]; thus, on the individual's ability of using this thing; and in turn, on the individual's performance while executing actions or tasks. In other words, the environmental factors may act as facilitators or barriers while an individual is using a designed thing. These factors may be classified into 2 groups:

- **Environmental factors *directly* related to the use relation:** They are environmental factors that undoubtedly affect at least one of the first 2 concepts on their way to affect the individual's ability of using designed things, in addition, the environmental factor '*external attitudes based on matters related to the use relation*'.
- **Environmental factors *indirectly* related to the use relation:** They are environmental factors that affect the user-designed thing relations of *access* or *harmony*, in addition, the environmental factor '*external attitudes based on matters related to the access or harmony relations*'. Actually, these factors *directly* affect the individual's ability of accessing to or harmonizing with the designed thing. *Indirectly*, these factors may have effects on the user's ability of using a designed thing via their effects on the user-designed thing relations of access or harmony.

The following describes how the environmental factors positively or negatively affect the user's ability of using designed things according to this classification.

---

[1] Environmental factors include the natural physical world, the man-made physical world, support by others, external attitudes and values, and finally services, systems and policies (rules and laws) (WHO: 2001, p. 213, 214). The appendix '*Environmental factors types*' provides more information.

[2] The other part is the personal factors that refer to all aspects of the internal world.

[3] They are *the user's body abilities (body functions and structures) related to using the designed thing*, *the designed thing characteristics related to use*, and *the user's decisions toward using the designed thing*.

2.6.1. Effects of the environmental factors on the user's ability of using the designed thing:

2.6.1.1: Effects of the environmental factors *directly* related to the use relation:

1. The natural physical world: It may affect the user's ability of using a designed thing via:

- affecting *the user's body abilities related to using the designed thing* (the 1st concept). For instance, a TV viewer may find difficulty in watching when his vision is compromised by bright light – especially people with reduced visual ability; a working environment in which the noise level of the environment is extremely high can affect negatively the hearing ability of an employee, resulting in the inefficient use and navigation through computer-based acoustic applications (Ashok, M.: 2009, p. 4-3) – especially people with low hearing ability; also, when the home heating unit is malfunctioning in winter, and with uncomfortable cold temperatures, an individual may suffer from temporary disabling conditions such as mild numbness in the fingers, and a general feeling of physical discomfort leading to a less than optimal computing experience (ibid.: p. 4-3). Conversely, the absence of the previous external factors or their presence with different values may act as facilitators while using the same things by the same users.
- affecting *the designed thing characteristics related to use* (the 2nd concept). For instance, a TV screen near a window may be perfectly viewable on a dull day, yet difficult to watch on a sunny afternoon (especially for people with low visual ability) – a situation that may be exacerbated if the user's vision is compromised by bright light (Clarkson, J.: 2007, p. 166). Also, a metal desktop continuously exposed to the sun may negatively affect the performance of its users.

2. The man-made physical world: It may affect the user's ability of using a designed thing via:

- affecting *the user's body abilities related to using the designed thing* (the 1st concept). For instance, a digital photo frame put on the desktop and sequentially displaying photos may act as a distracting stimulus and negatively affect the attention of a woman using her computer placed beside the frame; which in turn, may negatively affect her performance while using some computer-based applications. It's possible for her attention to be diverted and the quality of her performance to be affected (Ashok, M.: 2009, p. 4-4). On the contrary, the absence of distracting stimuli may positively affect the attention of an individual while using designed things.

- affecting *the designed thing characteristics related to use* (the 2nd concept). For instance, a computer user may find difficulty in using and navigating via applications on the computer screen which is affected by reflections of a mirror placed on the opposite side. Furthermore, well-acoustically isolated windows of a lecture hall affect positively the internal sound system – works as a facilitator, in turn, can positively affect the students' hearing ability, especially people with low hearing ability, thus, resulting in better comprehension.

3. Support by others:

The absence of support which may be offered by others to an individual in using a designed thing can have a negative influence on the individual's performance of using this thing; especially, designed things that he or she has no prior experience in their use or that their demands to be used exceed his or her current related body abilities levels. For example, the absence of support from others for an adult woman using a full heavy shopping cart and finding difficulty to lift it up the house stairs may negatively affect her ability of using the shopping cart. With the absence of support from others, the same might happen with an elderly trying to open a tightly closed water bottle; a man with a manual wheelchair trying to ascend a building ramp; or a worker who has no prior experience in using an upgraded machine with a new technology. Conversely, the presence of support by others *metaphor-ically* reinforces the current levels of related body abilities of the aforementioned individuals (the 1st concept) in the face of demands required for using the previous things.

4. Services, systems and policies:

The absence, presence and quality of services related to using a designed thing can have negative or positive effects on a user's ability of using this thing. Considering a service such as supplying residential consumers with electricity (one of the services for publicly provided utilities), an electricity shortcut in a person's home means that a notebook will depend on its charged battery to function, therefore, the screen becomes dimmer. Thus, this person may find difficulty in using and navigating through some computer-based applications, especially if he/she has a low visual ability. Recurrence or continuity of electricity shortcuts at home would make using the notebook more difficult. The same applies to using a car on low-quality vehicular transportation routes – one of the open space planning services. Additionally, side-walks without kerb cuts or with high-textured paving may act as barriers for a wheelchair user or a person pushing a baby carriage. Electricity shortcuts, unpaved routes and unplanned sidewalks increase the demands required for using the notebook, car, wheelchair and baby carriage respectively; these things appear as if they have different use-related characteristics (2^{nd} concept). Furthermore, the shortage of some of the previous services would negatively affect the users' body abilities related to using the designed thing (1^{st} concept) such as the notebook user's sight and locomotion and balance of the person pushing the baby carriage. Affecting one or both of the 2 concepts directly affects the state of the user's ability of using the above-mentioned designed things.

The effects of absence, presence and quality of services related to using a designed thing on a user's ability of using a designed thing reflect the efficiency of the systems organizing, controlling and monitoring these services and the policies governing and regulating these systems.

Additional effects:

The former 4 types of environmental factors may have *additional effects*, on the user's ability of using a designed thing. This is via affecting the 3^{rd} concept '*the user's decisions toward using this thing*'. Possible additional effects can be attributed to how the user perceives the effects of an environmental factor on the use relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user perceives the negative or positive effects of an environmental factor on his/her *body abilities related to using the designed thing* (the 1^{st} concept) or/and on *the designed thing characteristics related to use* (the 2^{nd} concept), thus on his/her ability of using this designed thing; and reacts to them via actions regarding the *participation*[1] and *adaptation*. Adaptation via modifying the designed thing characteristics related to use (incl. the normal method of using) – the 2^{nd} concept, features of the environmental factor when possible, or the user's body abilities related to using the designed thing (the 1^{st} concept) by depending on assisting aids (incl. medical devices), affects the 2 main pillars of the use relation and thus the quality of use interaction.

With a negative effect of an environmental factor on a user's ability of using a designed thing, he/she may perceive it at best as an *activator* and try to adapt to this negative effect

[1] *Participation* affects the occurrence and activation of the use interaction, and with the recurrence of participation, it affects the buildup of the user's experience of using this thing, which in turn affects his/her ability of using it.

accordingly, through modifying one or more of the use-related characteristics of this thing – incl. the normal method of using it, modifying one or more features of this factor when possible, or depending on assisting aids (incl. the medical devices). In turn, these adapting actions would positively affect the 2 main pillars of the use relation for this user and thus his /her ability of using this thing, and the buildup of his/her experience of using it and consequently his/her ability of using it. On the other hand, this negative effect may be perceived at worst as a *deactivator*. A user may be compelled to inefficiently and unsatisfactorily use this thing under the negative effect of features of this factor – especially with the impossibility of implementing the previous adapting actions. Also, he/she may avoid using this thing under the effect of this factor features, never use it again, or exceed this and avoid using similar designed things – at least in the same environment, in turn, this would negatively affect the buildup of his/her experience of using it and consequently his/her ability of using it. Conversely, an environmental factor acting as a facilitator for a user while using a designed thing may be perceived as an *activator* and positively affects his/her decisions toward using it, such as preferring to use it under the effect of this factor features; in turn, positively affects the buildup of his/her experience of using it and consequently his/her ability of using it.

5. External attitudes based on matters related to the use relation:

The external attitudes are those of people external to the user whose situation is being described. Negative or positive practices of people (individuals or society) – resulting from their negative and positive attitudes respectively – towards a user based on matters related to the use relation such as his/her body abilities levels related to using a designed thing, his/her body abilities levels related to using this thing as compared to others, his/her competence of using it or other similar designed things, his/her competence of using it or other similar designed things as compared to others, his/her method pursued in using it or similar designed things (adaptation), or his/her willingness to participate[1], may negatively or positively affect this user's ability of using this thing. This is through affecting the 3rd concept '*the user's decisions toward using this thing*'. Possible effects can be attributed to how this user perceives these practices – as *activators* or *deactivators*, and reacts to them with regard to using this thing. The user perceives these practices and reacts to them through actions

[1] These matters express the effects of all aforementioned personal factors and the first 4 environmental factors on the use relation.

regarding the *participation* and *adaptation*. Adaptation through modifying the designed thing characteristics related to use (incl. the normal method of use) – the 2nd concept, one or more features of the performance environment when possible, or *the user's body abilities related to using the designed thing* (the 1st concept) by depending on assisting aids (incl. medical devices), affects the 2 main pillars of the use relation and thus the quality of use interaction. This is clarified in the following:

- **Examples of external negative practices:**

- Stigmatizing or stereotyping *women* as having low dexterity abilities while using woodworking and gardening tools, unable to execute woodworking and gardening tasks, unwilling to do these tasks due to their hand size, or unable to perform these tasks as compared to men, may be perceived as a *deactivator* (a motivator for surrender – frustrating factor) and negatively affects the *actions* of a woman toward using these tools. She may avoid using such tools in the presence of these practices or never use them again; in turn, this would negatively affect the buildup of her experience of using them and consequently her ability of using them. On the contrary, another woman may perceive these *negative practices* as an *activator* (a motivator for challenge and improvement) and insist on using such tools and may resort to modifying one or more use-related characteristics of these tools – incl. the normal method of using them. In turn, these adapting actions would have a positive effect on her ability of using them, and the buildup of her experience of using them and consequently on her ability of using them.
- Stigmatizing or stereotyping *big-handed people* as having low dexterity abilities while using fine tools, unable to execute manual fine tasks, unwilling to do manual fine tasks due to their big hands, or unable to perform manual fine tasks as compared to small and normal-handed people, may be perceived as a *deactivator* (a motivator for surrender) and negatively affects the *actions* of a big-handed man toward using fine tools. He may avoid using such tools in the presence of these practices or never use them again; in turn, this would negatively affect the buildup of his experience of using them and consequently his ability of using them. On the contrary, another big-handed man may perceive these *negative practices* as an *activator* (a motivator for challenge and improvement) and insist on using such tools and may resort to modifying one or more use-related characteristics of these tools – incl. the normal method of using them. In turn, these adapting actions would have a positive effect on his ability of

using them, and the buildup of his experience of using them and consequently on his ability of using them.

- Stigmatizing or stereotyping Indonesians (a population, a group or cline members) tending to have small hands (*a clinal trait*) as having low dexterity abilities while using big handle tools, unable to execute related tasks, unwilling to do these tasks due to their small hands, or unable to perform these tasks as compared to others belonging to other clines having big hands, may be perceived as a *deactivator* (a motivator for surrender) and negatively affects the *actions* of an Indonesian man toward using big handle tools. He may avoid using such tools in the presence of these practices or never use them again; in turn, this would negatively affect the buildup of his experience of using them and consequently his ability of using them. On the contrary, another Indonesian man may perceive these negative practices as an *activator* (a motivator for challenge and improvement) and insist on using such tools and may resort to modifying one or more use-related characteristics of these tools – incl. the normal method of using them. In turn, these adapting actions would have a positive effect on his ability of using them, and the buildup of his experience of using them and consequently on his ability of using them.
- Stigmatizing or stereotyping a man (or a group) as having nihilistic or little experience (*novice*) in using a designed thing, unable to execute its related tasks, unwilling to do these tasks due to his low experience level, unwilling to improve his experience, or unable to perform these tasks as compared to others having enough or more experience (being skilled or expert) in using this thing, may be perceived as a *deactivator* (a motivator for surrender) and negatively affects the *actions* of this man toward using this thing or similar things. He may avoid using it in the presence of these practices or never use it again; in turn, this would negatively affect the buildup of his experience of using it and consequently his ability of using it. On the contrary, another man may perceive these negative practices as an *activator* (a motivator for challenge and improvement) and insist on using this thing. In turn, it would have a positive effect on his ability of using it, and the buildup of his experience of using it and consequently on his ability of using it. For example, stigmatizing or stereotyping older people as having little experience in using IT products, unable to execute its related tasks, unwilling to do these tasks due to their low experience level, unwilling to improve their experience, or unable to perform these tasks as compared to children and young adults having enough or more experience in using IT products, may negatively or positively affect an old man's actions

toward using IT products according to how he perceives that – as a motivator for surrender or improvement.

- Stigmatizing or stereotyping the *elderly* as having limited body abilities, having less skill in using IT products, unwilling to improve their low ability in using IT products, or being less competent in doing IT tasks in comparison to children and young adults, may negatively or positively affect an old woman's actions toward using IT products according to how she perceives that – as a motivator for surrender or improvement.[1]
- Also, the argument regarding the other personal factors *directly* related to the use relation and the first 4 environmental factors *directly* related to the use relation, conducts the same way.

▪ **Examples of external positive practices:**

- Stigmatizing or stereotyping *women* as having high dexterity abilities while using fine tools, able to easily execute manual fine tasks, willing to do them due to their hand size, or able to perform manual fine tasks better than men, may be perceived as an *activator* (a motivator for progress and distinction) and positively affects the *actions* of a woman toward using a fine tool; in turn, this would positively affect the buildup of her experience of using it and consequently her ability of using it. Conversely, another woman may perceive these positive practices as a *deactivator* (a motivator for laziness, slouching, slackness or carelessness) while using the same tool; thus, these positive practices have a negative effect on the buildup of her experience of using it; consequently on her ability of using it.
- Stigmatizing or stereotyping *small-handed people* as having high dexterity abilities while using fine tools, able to easily execute manual fine tasks, willing to do them due to their small hands, or able to perform manual fine tasks better than big and normal-handed people, may be perceived as an *activator* (a motivator for progress and distinction) and positively affects the *actions* of a small-handed man toward using a fine tool; in turn, this would positively affect the buildup of his experience of using it and consequently his ability of using

[1] Also, stigmatizing or stereotyping *impaired people* as having low body abilities, being disabled to execute related tasks, being unwilling to do related tasks due to their impairment, or being less competent in doing related tasks as compared to able-bodied people, may negatively or positively affect an impaired man's actions toward using a designed thing according to how he perceives that as a motivator for surrender or improvement.

it. Conversely, a small-handed man may perceive these positive practices as a *deactivator* (a motivator for laziness, slouching, slackness or carelessness) while using the same tool; thus, these positive practices have a negative effect on the buildup of his experience of using it; consequently on his ability of using it.

- Stigmatizing or stereotyping Indonesians (a population, a group or cline members) tending to have small hands (a *clinal trait*) as having high dexterity abilities while using fine tools, able to easily execute manual fine tasks, willing to do them due to their small hands, or able to perform manual fine tasks better than others belonging to other clines having big hands, may be perceived as an *activator* (a motivator for progress and distinction) and positively affects the *actions* of an Indonesian man toward using a fine tool); in turn, this would positively affect the buildup of his experience of using it and consequently his ability of using it. On the contrary, another Indonesian man may perceive these positive practices as a *deactivator* (a motivator for laziness, slouching, slackness or carelessness) while using the same tool; thus, these positive practices have a negative effect on the buildup of his experience of using it; consequently on his ability of using it.
- Stigmatizing or stereotyping a man (or a group) as *skilled* or *expert* in using a designed thing, able to easily execute its related tasks, willing to do them due to his high experience level, willing to improve his experience, or able to perform these tasks better than others being novice, may be perceived as an activator (a motivator for progress and distinction) and positively affects the *actions* of this man toward using this thing or similar things; in turn, this would positively affect the buildup of his experience of using it and consequently his ability of using it. Conversely, another man may perceive these positive practices as a *deactivator* (a motivator for laziness, slouching, slackness or carelessness) while using the same designed thing; thus, these positive practices have a negative effect on the buildup of his experience of using it; consequently on his ability of using it.
- Also, the argument regarding the other personal factors *directly* related to the use relation and the first 4 environmental factors *directly* related to the use relation, conducts the same way.

2.6.1.2: Effects of the environmental factors *indirectly* related to the use relation:

1. Environmental factors affecting the user-thing relations of access or harmony:

Some environmental factors affect the individual's ability of accessing to or harmonizing with designed things – see e.g. section 3.3. These factors may have additional effects but on the user's ability of using a designed thing. This is through affecting the 3rd concept '*the user's decisions toward using this thing*'. Possible effects can be attributed to how the user perceives the effects of an environmental factor on the access or harmony relation – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user perceives the negative or positive effects of an environmental factor on his/her ability of accessing to or harmonizing with this designed thing and reacts to them through actions related to the *participation* and *adaptation*. Adaptation via modifying *the designed thing characteristics related to use* (the 2nd concept) affects the 2nd pillar of the use relation and thus the quality of use interaction.

2. External attitudes based on matters unrelated to the use relation (related to the access or harmony relations):

The external attitudes are those of people external to the user whose situation is being described. Negative or positive practices of people (individuals or society) – resulting from their negative and positive attitudes respectively – towards an individual based on matters related to the access or harmony relations such as his/her empowerment- or ideology-related characteristics, empowerment- or ideology-related characteristics as compared to others, competence of accessing to or harmonizing with a designed thing or other similar designed things, or competence of accessing to or harmonizing with a designed thing or other similar designed things as compared to others, may negatively or positively affect this user's ability of using this thing. This is through affecting the 3rd concept '*the user's decisions toward using this thing*'. Possible effects can be attributed to how this user perceives these practices – as *activators* or *deactivators*, and reacts to them with regards to using this thing. The user perceives these practices and reacts to them through actions regarding the *participation* and *adaptation*. Adaptation via modifying *the designed thing characteristics related to use* (the 2nd concept) affects the 2nd pillar of the use relation and thus the quality of use interaction.

2.6.2. Clarifications:

For a more detailed clarification about the effects of an environmental factor on the user's ability of using a designed thing, it's worth to be mentioned that:

1. Environmental factors acting as *facilitators* are factors in a person's performance environment that, via their features (absence, presence, values or qualities), *improve functioning* and *reduce disability* while he/she is using a designed thing, thus, while he/she is executing related actions or tasks – they're environmental factors influencing the quality of interaction between a user and a designed thing in a positive way. Environmental factors acting as *barriers* are factors in a person's performance environment that, via their features, *limit functioning* and *create disability* while he/she is using a designed thing, thus, while he/she is executing related actions or tasks – they're environmental factors influencing the quality of interaction between a user and a designed thing in a negative way. (WHO: 2001, p. 214)
2. Some environmental factors can act as *barriers* due to their *presence* (e.g. negative attitudes towards people with impairments), while other environmental factors can act as *barriers* due to their *absence* (e.g. the unavailability of a needed service) (ibid: p. 171). Similarly, some environmental factors can act as *facilitators* due to their *presence* (e.g. the availability of a needed service), while other environmental factors can act as *facilitators* due to their *absence* (e.g. absence of stigma or negative attitudes towards people with impairments).
3. The negative or positive effect of an environmental factor on the user's ability of using a designed thing may be absent, mild, moderate or substantial.
4. An environmental factor is classified as being either a facilitator and to what extent or a barrier and to what extent, from 2 perspectives. Firstly, the perspective of the person whose situation is being described, e.g. kerb cuts without textured paving may be a facilitator for a wheelchair user but a barrier for a blind person (ibid.: p. 171); and secondly, the perspective of the designed thing being in use, e.g. a television screen near a window may be perfectly viewable on a dull day, while reading a newspaper may not be legible – especially for people with low visual ability.

2.6.3. Dynamism – Changeability of the performance environment characteristics – Effect of time change:

As mentioned before, the performance environment as a medium is an integrated context of the numerous environmental factors whose current features (absence, presence, values and/or qualities) make up its corresponding physical, social and attitudinal characteristics. *With time*, some of these features may be unchangeable and some may be *ever-changing* or *changeable*. Changes may happen slowly or quickly, regularly or irregularly, and may range from minor to radical. Actually, changeability of the characteristics (*dynamism*) of a performance environment readily takes place; so, it may be considered a *dynamic unit*. Hereby, on an individual's level, changes in the characteristics of a particular environment may have a different impact on (may be dramatic) a user's performance while using the same designed thing in that environment before and after the change. For example, using a notebook to complete an assignment in a quiet office might produce startlingly different results if the same individual was to use the same notebook in the same office but in a noisy and dynamic state. Also, for an individual, a television screen near a window may be difficultly viewable on a sunny day, yet perfect to watch on a dull day.

2.6.4. Variety and plurality of the potential performance environments:

Each performance environment has its own physical, social and attitudinal characteristics resulting from the current features (absence, presence, values and/or qualities) of the many environmental factors. Such characteristics *distinguish* performance environments from each other and express the extent of differences among them. Differences in these characteristics among environments may range from very low to very high according to differences in their own features of the same environmental factors. *Diversity* of the performance environments – being probably *dynamic units* – regarding such characteristics is an indisputable fact. In turn, differences in such characteristics among performance environments may lead to corresponding differences in abilities levels of using a designed thing or completing related tasks. On an individual's level, different performance environments may have different impacts on the performance of the same individual while using the same designed thing[1] or other copies of it in these different environments. An environment with barriers, or with-out facilitators, will hinder the individual's performance; other environments that are more facilitating may

[1] – such as notebooks, e-book readers and cell phones are used in different environments by the same person.

increase that performance (ibid.: p. 17); e.g. using a personal computer to complete an assignment in a quiet office might produce startlingly different results if the same individual was to use the same computer in an active, noisy kitchen (Ashok, M.: 2009, p. 4-4). On the collective level of individuals, and by excluding things designed for use in specific environments, countless copies[1] of a designed thing are being used by different users in different environments which may have different impacts on the users' performance while using them. *Dynamic diversity* of the environments in such characteristics is an essential aspect that must be considered while designed things are created.

Due to the reason that most designed things are created not to be used in (aren’t custom made for) a specific performance environment, *plurality/plenty* of performance environments – being already *diverse* and probably *dynamic* – in which a designed thing or copies of it may be used, readily takes place; in a world where most designed things have moved across borders, there’s a sheer increase in the number of diverse performance environments in which such things are used.

[1] In a world where most designed things have moved across borders, there's a sheer increase in the number of diverse performance environments in which a copy of a designed thing may be used.

2.6.5. Conclusion:

To conclude the former debate regarding the performance environment, it could be briefly stated that:

1. The environmental context in which a designed thing is used encompasses a larger group of factors and not just the physical environment surrounding the user (Sears, A.: 2003), or the factors with which the user comes face to face or has a direct contact (WHO: 2001, p. 16).
2. The physical environmental factors include a wide range of elements belonging to the natural or the man-made physical world.
3. The *environmental factors* play a significant role in affecting the user's ability level of using a designed thing and doing its related tasks, through affecting one or more of the following 3 concepts: *the user's body abilities related to using the designed thing*, *the designed thing characteristics related to use* and *the user's decisions toward using the designed thing*. The performance environment can enhance or hamper the *user's experience*; the impact can be particularly significant for people with reduced body ability levels (Coleman, R.: 2007, Inclusive design process, p. 2-26). This reflects the importance of the performance environment in the wider context of *user-designed thing interaction*.
4. Not only the environmental factors *directly* related to the use relation affect the user's ability of using the designed thing, but also the environmental factors *indirectly* related to the use relation (*directly* related to the access or harmony relations) – table 2.4.
5. In addition to the aspects resulting from the effects of the personal factors on the *aforementioned 3 concepts*, the effects of the environmental factors result in some other considerable aspects – table 2.4. These aspects are represented in:

- *The performance environment-induced biological state of the user's body systems related to using the designed thing*. It's concerned with to what extent his/her related body systems function well in the performance environment. It's based on the physical and physiological measures of these systems in the performance environment and reflects the effects of some environmental factors directly related to the use relation on the own biological state of these systems. *Aspect Nr. 2*
- *The performance environment-induced state of the designed thing characteristics related to use*. It's concerned with the state of its original characteristics related to use in the perform-

ance environment. It's concerned with temporary or permanent changes that may occur in these characteristics by effects of some environmental factors directly related to the use relation. *Aspect Nr. 4*

- *The user's decisions toward using the designed thing induced by environmental factors directly related to the use relation* due to their effects on the use relation[1] or due to other matters related to these effects (matters considered by the user such as external attitudes based on matters related to the use relation). These decisions reflect the user's current psychological state toward both): 1- the effects of these factors on his/her body abilities (even if *metaphorically*[2]) related to using the designed thing (the 1st concept), on the designed thing characteristics related to use (the 2nd concept), and on his/her ability of using this designed thing; 2- external attitudes based on matters related to the use relation. These decisions are materialized through the user's actions regarding his/her *participation* and *adaptation*[3] which form his/her engagement state in using this thing. *Aspect Nr. 7*
- *The user's decisions toward using the designed thing induced by environmental factors directly related to the access or harmony relations* (indirectly related to the use relation) due to their effects on the access or harmony relations respectively or due to other matters related to these effects (matters considered by the user such as external attitudes based on matters related to the access or harmony relation). These decisions reflect the user's current psychological state toward both: 1- the effects of these factors on his/her empowerment- or ideology-related characteristics related to accessing to or harmonizing with the designed thing respectively, and on his/her ability of accessing to or harmonizing with this designed thing; 2- external attitudes based on matters related to the access or harmony relation. These decisions are materialized through the user's actions regarding his/her *participation* and *adaptation*[4] which form his/her engagement state in using this thing. *Aspect Nr. 9*

---

[1] – through their role in forming the *aspects Nr. 2 & 4* of the use relation, thus in interaction competence of it.

[2] – when the personal factor is the *support by others*.

[3] *Adaptation* via modifying the designed thing characteristics related to use (incl. the normal method of use) – the 2nd concept, or modifying the user's body abilities related to using the designed thing (the 1st concept) via depending on assisting aids (incl. medical devices), affects the 2 main pillars of the use relation and thus the quality of usage interaction; adaptation aims to improve the ease of using the designed thing.

[4] *Adaptation* via modifying the designed thing characteristics related to use (incl. the normal method of use) (the 2nd concept), affects the 2nd pillar of the use relation (current demands of using the designed thing) and thus the quality of usage interaction. Adaptation aims to improve the ability of access to or harmony with the designed thing.

- *The assisting aids-induced biological state of the user's body systems related to using the designed thing*, being a user's reaction to (a form of adaptation to) the environmental factors *directly* related to the use relation due to their effects on this relation or due to other matters related to these effects (matters considered by the user such as external attitudes based on matters related to the use relation) – see *aspect Nr. 7*. It's concerned with temporary and permanent changes that may occur in the own biological state of the user's body systems related to using the designed thing by the user through depending on assisting aids (incl. medical devices). *Aspect Nr. 3.2*
- *The user-induced state of the designed thing characteristics related to use*, being a user's reaction to (a form of adaptation to) the environmental factors directly related to the use, access or harmony relations (all environmental factors directly or indirectly related to the use relation) due to their effects on these relations respectively or due to other matters related to these effects (matters considered by the user such as external attitudes based on matters related to the use, access or harmony relation). It's concerned with temporary and permanent changes that may occur in the original use-related characteristics of the designed thing (incl. the method of use) by the user as a reaction to the environmental factors directly or indirectly related to the use relation – see *aspects Nr. 7 and 9*. *Aspect Nr. 5.2*

6. The performance environment is sometimes a *dynamic unit*. Features (absence, presence, values and/or qualities) of some environmental factors making up the characteristics of a performance environment are *changeable with time*. In turn, changes in related features may differently impact the user's performance of using a particular designed thing in this performance environment.

7. According to the own features of the numerous environmental factors, performance environments are *diverse* in their physical, social and attitudinal characteristics. In turn, different environments, in which a particular designed thing is intended to be used, may show varying impacts on the performance of an individual during usage – may lead to corresponding differences in an individual's ability level of using this thing or completing related tasks. Also, the *plurality* of performance environments – being already *diverse* and probably *dynamic* – in which a designed thing or copies of it may be used, is a permanent occurrence. The *dynamic diversity* of performance environments in these characteristics is an essential aspect that must be considered while designed things are created, and the *plurality* of the possible performance environments makes it more essential and challenging.

Dynamism - Changeability of the performance environment characteristics

Variety of the potential performance environments

Environmental factors		Concepts: The user's body abilities related to using the designed thing	The designed thing characteristics related to use	The user's decisions toward using the designed thing
Environmental factors *directly* related to the use relation	The natural physical world	✓ Aspect 2	✓ Aspect 4	✓ Aspect 7
	The man-made physical world	✓ Aspect 2	✓ Aspect 4	✓ Aspect 7
	Support by others	metaphorically ✓ Aspect 2		✓ Aspect 7
	Services, systems and policies	✓ Aspect 2	✓ Aspect 4	✓ Aspect 7
	External attitudes			✓ Aspect 7
Environmental factors *indirectly* related to the use relation	The natural physical world			✓ Aspect 9
	The man-made physical world			✓ Aspect 9
	Support by others			✓ Aspect 9
	Services, systems and policies			✓ Aspect 9
	External attitudes			✓ Aspect 9
		✓ Aspect 3. 2	✓ Aspect 5. 2	

Adaption

Adaption

Participation

Interaction

Table 2.4: It shows the different aspects resulting from the effects of the environmental context on the 3 main concepts, thus on the user's ability of using a designed thing. Also, it points out the *changeability* of these effects according to the *changeability* of the performance environment characteristics with time (*dynamism*), and the *variety* of potential performance environments in which a designed thing or copies of it might be used.

2.7. What should actors and design practices consider?

Actors should keep in mind that

- evaluating a function or an ability of a body system via evaluating only one of its aspects;
- reducing the body-related characteristics to those related to macroscopic/visible physical measures (gross anatomy) at the expense of microscopic/invisible physical measures (microscopic anatomy) and physiological measures – section 2.4;
- overlooking partly or totally the effects and their extent of the *personal factors directly or indirectly related to the use relation* on the *3 aforementioned concepts*, thus on the user's ability level of using a designed thing – see the previous considerable aspects in section 2.5.4;
- limiting the affecting personal factors to *some* of those *directly* related to the use relation such as ageing and impairment;
- overlooking the *changeability* of most of the user's characteristics and its *varying impact* on his/her ability of using the same designed thing;
- overlooking the *diversity* of the possible users in their characteristics and its corresponding *diversity* in their abilities levels of using the same designed thing;
- overlooking the *plurality* of the possible users being already *diverse* and *dynamic* in their characteristics;
- overlooking partly or totally the effects and their extent of the *environmental factors directly or indirectly related to the use relation* on the *3 aforementioned concepts*, thus on the user's ability level of using a designed thing – see the previous considerable aspects in section 2.6.5;
- limiting the affecting environmental factors to the physical ones surrounding or having direct contact with the user;
- overlooking the *changeability* of the performance environment characteristics and its *varying impact* on the user's ability level of using the same designed thing;
- overlooking the *diversity* of the possible environments in which a designed thing or copies of it might be in use, and its corresponding *diversity* in the user's ability level of using the same designed thing;
- or/and overlooking the *plurality* of possible environments in which this thing or copies of it might be in use, and being already *diverse* and probably *dynamic* in their characteristics;

may at best lead to difficulty or frustration for some expected users while using this thing, and at worst lead to their inability to use it. In both cases, those users are vulnerable to *design exclusion*. Here, difficulties, frustrations and inabilities of using this thing (expressing design exclusion) don't come about by chance; they come about through the shallow understanding of the user-designed thing relation of use, negligence, ignorance and lack of adequate information and data about the *potential end-users* who might use this thing or a copy of it and about the *potential performance environments* in which this thing or copies of it might be used.

So, designing with *all effects and their extent of the contextual factors* on usability in mind helps create a thing that *may be well used*; and designing with *these effects*, *changeability of the user's and performance environment characteristics*, and the *variety* and *plurality of the potential end-users and performance environments* in mind helps create a thing that *may be widely well used (equally usable) for a long time*.

While it would be strenuous to come up with all effects and their extent of all contextual factors) on an end-user's abilities of using a designed thing, actors need to be aware of the maximal number of them. Also, while it would be impossible to come up with all various potential end-users and performance environments of a designed thing and all changes that may occur with time in most of their characteristics, it's important for actors to imagine typical and not so typical characteristics of the potential end-users and performance environments for creating *realistic scenarios of usage* for their designed things. Although it isn't possible to make all designed things easily usable for everyone – for every use context, these realistic scenarios can help extend the usability of mainstream designed things and maximize the number of potential end-users.

2.8. Design exclusion regarding usability:

2.8.1. Design exclusion regarding usability related to personal factors:

Initially, 'designers are trained to design for a mythical 'average' group of people' (Story, M.: 1998, p. 2); until recently, architects and professional designers working on the development of designed things tend to treat people as *universal types* rather than individuals (Cassim, J.: 2007, Why Inclusive Design? p. 11). In other words, they depend on the average – not the wide range – of the biological (physical & physiological) measures[1] of the people while they create designed things. In this way, they are designing for *uniform* or *standard* people, and people whose measures are outside the narrow range of average, are vulnerable to design exclusion, and consequently, their needs may not be met. Those excluded people – such as impaired and older people – are treated as special cases or groups falling outside the mainstream and requiring special design solutions (ibid.: p. 12). Often this is seen as the person's fault for having a poor memory, reduced strength or imperfect vision (Coleman, R.: 2007, Intro., p. 1-22).

In our current era of rapid economic expansion starting from the mid. of the last century and characterized by design for mass or flow production as the *main paradigm of design*, people have been treated as *universal types*. In 1960, the US industrial designer Henry Dreyfuss established the study of anthropometrics – the dimensions of scale including arm and leg reach – through his text '*The Measure of Man*' as an essential tool for designers. (Cassim, J.: 2007, Why Inclusive Design? p. 11)

> *The impact of The Measure of Man was profound, and its thinking influenced the design of everything from workplaces, homes and public buildings to furniture, appliances and transport. Dreyfuss measured hundreds of men, women and children and calculated mean averages and dimensional ranges, intended to underpin design decision-making for mass production. This gave rise to a one-size-fits-all approach, which allowed for the volume production of affordable goods that fuelled the growth of consumerism. Great social and economic benefits ensued for the majority of people, but those who did not conform in terms of height, weight, cognitive or sensory capacity or physical strength became vulnerable to design exclusion. And as a consequence their needs were not addressed through mainstream mass production.* (ibid.: p. 11)

[1] (expressing the body abilities levels)

For example, the BAHCO tools are good ergonomic design for professional craftsmen, but aren't good examples of equally usable design: there's only one size of each tool, usually designed for an average man (Dong, H.: 2007, p. 59). Treating people as universal types ignores the *diversity* of people in their biological (physical and physiological) characteristics being already *dynamic* or *changeable with time*. So, the current paradigm of design has been based on what could be known as the '*elusive average user*'. Relying on the average is misleading because it unintentionally excludes people although they are considered when the averages are calculated. Even if they are small proportions, in big groups of people, small proportions make up a large number of people that can't be underestimated.

Also typically, people are viewed as being either able-bodied or impaired, male or female, older or young adult, with things being designed for one category or the other (Coleman, R.: 2007, Intro., p. 1-22). Treating people as 2 groups enhances the chances of excluding a group of them.

Additionally, the past and current attempts to include specific groups of those excluded – such as the elderly and impaired for using the mainstream designed things (see section 2. 12) – are a great valuable effort. But *limiting* the personal factors to *ageing* and *impairment* considers a new form of exclusion for the other groups being already excluded, and again drifts us away from *equity* and *inclusivity*.

2.8.1.1. Examples of design exclusion regarding usability related to personal factors:

'Exclusion by design is commonplace, both at home and in the workplace. It also represents the extreme reaction to poor design which leaves many frustrated or facing difficulty, even if not excluded' (Clarkson, J.: 2007, p. 178).

1. Airlines – Design exclusion led to death:

Quoting from the Daily Mail, Jill Reilly wrote the following article on 26 November 2012 under the heading, *Too FAT to fly: Sick American woman dies in Hungary after 'airline kicks her off three New York flights because she was too obese'*.

> *A U.S woman died on holiday in Hungary after being refused a seat on three flights back to New York because she was too heavy to fly, according to her husband. Vilma Soltesz, 56, from New*

York, had weighed about 425 pounds[1], had only one leg and used a wheelchair. She died from health complications in Hungary nine days after she was kicked off the first of three flights and now her death could now be the cause of a multimillion-dollar lawsuit against the airlines.

Before the journey, their travel agent informed Delta of Mrs. Soltesz's condition and they planned to return on October 15 so Mrs Soltesz could continue her medical treatment for her illness - a combination of kidney disease and diabetes.

Mr. Soltesz said his wife was already seated on the plane when they were asked to leave by KLM. 'They tried to fit her into the back of the plane, but they didn't have an extension to secure her,' he said. She had gained weight due to her illness and the airline said it did not have a seat-belt extender for her, Mr. Soltesz said. He was also told the seat back could not take his wife's weight.

After leaving the airplane, the couple waited in the airport for several hours and then were told to drive five hours to Prague for a Delta plane that could accommodate her as a disabled person. But in Prague, Delta staff told the couple the airline's plastic wheelchair could not hold her weight and the staff also couldn't put her on the sky-lift elevator. The couple, who were born in Hungary, were forced to return to their holiday home until their New York travel agent managed to get them on an October 22 Lufthansa flight to New York via Frankfurt, which would be able to accommodate her size.

Although a local fire department were brought in to help move Mrs. Soltesz into three seats assigned to her, they could not lift her out of the wheelchair. After half an hour of trying to move her, the captain asked them to leave the plane. 'We had 140 passengers on board, and they had connections and needed to travel,' said Lufthansa spokesman Nils Haupt. 'The question was never the seat belt. The question was the mobility of the passenger.' But when they returned to their holiday home again to make alternative arrangement Mrs. Soltesz became more poorly.

The couple did not opt to see a doctor in Hungary as they felt the staff would not be familiar with her medical needs, and two days later Mrs. Soltesz died and she was buried in Hungary.

Now attorney Holly Ostrov Ronai, who is considering a multimillion-dollar lawsuit against the airlines accusing them of violating laws protecting the disabled.

'KLM is deeply saddened by the death of Mrs. Vilma Soltesz and would like to offer its heartfelt condolences to her family. We have outlined the facts below: it appeared on the passenger's return that it was not physically possible for her to board the aircraft, despite every effort made by KLM to this end. A seat or belt extender did not offer a solution either,' said a KLM spokesperson.

'After the operating carrier in Budapest was physically unable to board Mrs. Soltesz on its flight, and despite a determined good-faith effort by Delta in Prague, we were also physically unable to board her on our aircraft,' said Delta spokesman Russel Cason to the New York Post.

[1] – approx. 193 Kg

Simply, excluding Mrs. Soltesz from *equally using* many designed things, clarifies that many designed things haven't been *equally* created to be *easy to use* (*easily usable*), or that some personal factors such as abnormality of body measures and impairment haven't been considered in the design process. The seatback of the KLM plane not taking Mrs. Soltesz weight, the seat-belt needing a belt extender to secure her, the airline's plastic wheelchair in Prague not holding her weight, and the planes not being prepared to accommodate wheelchairs or overweight people, are clear examples that the *diversity* of people characteristics hasn't been included in the scope of design practices or addressed through the design process.

2. The kettle:

> *Assuming that the kettle is positioned to suit the height and mobility of the user, the basic actions required are: to pick up the kettle; carry it to the nearby water tap; fill the kettle with water; return it to its base; switch it on; and pour the boiling water into a cup. A level of user exclusion can then be calculated by assessing the levels of each of the functional capabilities[1] required to undertake these actions and estimating the number of users unable to meet these demands. ……. One could argue that the predominant purpose of a kettle is to provide hot water for making drinks and, in that context, an ideal kettle might be one that is no more difficult to use than drinking from a cup. The target population for an ideal kettle could therefore be all those users who can safely drink from a cup full of hot drink.* (Clarkson, J.: 2007, p. 173, 174)

Depending on valid data about the number of people with body abilities loss in the UK and the type and degree of loss and with assessing the levels of each of the functional capabilities required to comfortably use a typical 1.7-litre stainless steel kettle shown in fig.2.7, John Clarkson (2007) found that 5.3% (2,506,000 persons) of those 15+ wouldn't be able to use such a kettle. Further analysis shows that only 486,000 persons can't drink from a cup, thus, are unable to use such a kettle. This suggests that there are over 2 million people in the UK who can drink from a cup but are unable to use such a kettle to boil water (ibid.: p. 174).

Fig. 2.7: A typical 1.7-litre stainless steel kettle (Clarkson, J.: 2007, p.174)

[1] (levels of human body abilities)

3. The digital television:

'Digital terrestrial television (DTV) equipment and services are significantly different from their current analogue counterparts, often using a separate set-top box with its own, additional, remote control' (ibid.: p. 174, 175). For estimating the number of UK households that would have difficulty adopting the new digital technology, an assessment report of current DTV equipment undertaken for the UK Department of Trade and Industry (DTI) (DTI: 2006), estimated that 2.0 million households contain someone who will be excluded from using current DTV equipment (incl. 1,2 million with severe sensory, cognitive or motion capability loss and 0.8 million of those with mild sensory, cognitive or motion capability loss); and 8.9 million households contain someone who may have difficulty using current DTV equipment (incl. 2.7 million with mild sensory, cognitive or motion capability loss and 6.2 million able-bodied who have a fear of or unfamiliarity with technology) (ibid.: p. 175, 176).

For more common examples of design exclusion regarding usability in our daily life, see p. 41.

2.8.2. Design exclusion regarding usability related to environmental factors:

Actually, most design studies, curriculums, postgraduate programmes and books – *unfortunately, usability-related ones* – have reduced the wide range of environmental factors and their effects into some of the physical ones (temperature, background noise and ambient lighting). This has been shown clearly in their theoretical contents, mentioned examples and clarified case studies. For example, see (Clarkson, J.: 2007, Inclusive Design Toolkit) and (Coleman, R.: 2007, Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design). Also, the MSc/Diploma programme of '*Human Factors for Inclusive Design*' – September 2019, at Loughborough University, UK, goes the same way; regarding the aim of its '*Environmental Ergonomics*' module, it's to enable students to measure and understand the effects of the physical environment on humans, and to provide the basic principles and practice of environmental ergonomics including general philosophy and the effects of noise, vibration, heat, cold, thermal comfort, vision and lighting[1]. In addition, according to my personal experience, all undergraduate design curriculums in Egyptian design faculties and institutes confirm this; the same applies to the undergraduate curriculums of the Faculty of Art and Design at the University of Kassel – Germany. All of this narrows the perception of the majority of design practitioners regarding the wide range of environmental factors and their effects on the user's ability of using the designed thing. So, it wouldn't be strange when some targeted users find difficulty in using a designed thing or are unable to use it, although it's used for its predetermined purposes.

Also, usability tests don't take place in the performance environment in which the designed thing will ultimately be used (Bremner, C.: 2008, p. 426). They are generally done in a *uniform* or *standard environment* where the features of environmental factors are under control and not completely identical to the ones of the performance environments. Using a standardized environment to test the usability of a designed thing ignores the different effects of different features of the environmental factors in a realistic performance environment, neutralizes the varying impact resulting from the changeability of its environmental factors features, and neutralizes the varying impact of different environments on the user's ability of using this designed thing. Testing the *usability* of a designed thing in a *standard environment* targets the highest probable level of *functioning*/*ability* of using it that the expected user may attain – the full ability of the user of using it (capacity). This frequently differs from his/her ability

[1] lboro.ac.uk/study/postgraduate/masters-degrees/a-z/human-factors-inclusive-design/

level of using it in the *actual environment* (*performance*)[1]. Thus, usability testing results are frequently misleading. So, the current paradigm of design has been based on what could be known as the '*elusive standard environment*'.

Although the gap between *capacity* and *performance* reflects the difference between the impacts of *uniform* and *actual* environments, and thus provides a useful guide as to what can be done to the environment of the individual to improve performance (WHO: 2001, p. 15); the individual finds it necessary to undertake modifications to one or more features of the performance environment when possible, or one or more of the use-related characteristics of this thing – incl. the normal method of using it – for using it comfortably. Actually, not all necessary modifications are in the hands of users – see the next example, and inability to undertake them means that users are obliged to uncomfortably, inefficiently or dependently use it or do away with it. In all cases, design practitioners are like throwing fireballs into the users' territory, and this hinders a designed thing from being well used, and more importantly, widely well used.

2.8.2.1. An example of disregarding the actual environmental context through the design process:

Normally, the car is parked adjacent to the sidewalk so as not to block or cramp the street and to allow its users (driver and passengers) to get in the car directly from the sidewalk and out of the car directly to the sidewalk – fig. 2.8. Thus, sidewalks shouldn't exceed a specific height to facilitate stepping in and out of the car, especially for people with low locomotive ability, and allow the smooth opening of the car doors.

In Egypt, where most sidewalks are abnormally higher than the street level, traffic is always very heavy, and cars are either imported or domestically assembled, and by excluding cars with elevated bottoms (chassis), users of cars with mid-rise and low-rise bottoms may find difficulties in getting in and out of the car parked adjacent to the sidewalk – fig. 2.9. Additionally, with extremely elevated sidewalks, it gets more complicated when the car door can't be opened or when the lower edge of the car door rubs the sidewalk while trying to open the car door – fig. 2.10. This urges car drivers to stop their cars distant from the sidewalk to allow

[1] Whereas *performance* indicates the ability level of doing a task or an action in the execution or *actual* environment, *capacity* indicates the highest probable ability of the individual to execute the same task or action in a *standard* environment. *Capacity reflects the environmentally adjusted ability of the individual*. (WHO: 2001, p.11, 15, 214)

passengers (incl. sometimes the driver himself) using the car doors alongside the sidewalk to easily open the doors and comfortably get in and out of the car. On the other hand, passengers (often incl. the driver) using the car doors not alongside the sidewalk are insecure – they and the car may be exposed to accidents. In addition, this could increase the already aggravating traffic conditions.

This example shows how the quality of sidewalks – one of the open space planning services – could affect an individual's performance while using a car. In addition, it clarifies how *design practices* don't consider the effect of the actual *environmental context* or the varying impacts of the various *environmental contexts* in which cars might be used on the individuals' performance while using cars; here, the reality of related features of the Egyptian environment isn't considered. In this way, difficulties and risks facing individuals using cars with mid-rise and low-rise bottoms may give preference to cars with elevated bottoms in the Egyptian market. According to reports released by the Central Agency for Public Mobilization and Statistics (CAPMAS) in Egypt, approx. 190000 cars have been licensed in the 2nd half of 2015 (Alwafd: 2016, Moheet: 2015). This annually makes up approx. 0,006 % of 68.56 million cars produced worldwide in 2015 (Statista: 2016), in turn, this reflects the consuming power of the Egyptian market.

Designing with possible environmental contexts in mind – such as environments with elevated sidewalks – *helps create improvements in the cars with mid-rise and low-rise bottoms.* Modifications, such as the automatically controlled height adjustable bottom[1] of the car while it's parked, may be a theoretically questionable suggestion. Modifications made to a car model, at least for cars directed to a *particular environmental context* (e.g. the Egyptian market), could make the car widely used and, more importantly, widely well-used. These modifications may give this model an added value (or new characteristics) represented in controlling the height of the car bottom according to the situation. This may give the car a competitive or marketing advantage and it may be marketed in other markets as well. Also, these modifications may be valuable in other environments, such as environments where streets are flooded by rains or covered by heavy snow, or environments with rough terrains.

[1] Practically, some cars use height adjustability as part of active suspension systems to improve the vehicle's versatility on- and off-road – a current example being the Mercedes-Benz Active Body Control system and the Audi A8 (Wikipedia: Height adjustable suspension). Active suspension is a type of automotive suspension that controls the vertical movement of the wheels relative to the chassis or vehicle body with an onboard system, rather than in passive suspensions where the movement is being determined entirely by the road surface (Wikipedia: Active suspension)

Fig. 2.8: The ideal relation between a car and a sidewalk could help a user get in and out of the car.

Fig. 2.9: Difficulties in getting in and out of the car adjacent to an elevated sidewalk urging a car driver to stop far away from the sidewalk.

Fig.2.10: An extremely elevated sidewalk than the street level urges a car driver to stop far away from the sidewalk.

2.9. Is there an urgent need to change?

Referring to the aforementioned examples of *design exclusion* regarding *usability* related to personal and environmental factors in section 2.8, what is so often evident is that *no one* in the design chain has indeed considered the *diversity of dynamic contexts* (diversity of dynamic users and performance environments) resulting from the effects of all *contextual factors, directly and indirectly, related to the use relation*, because if they had, then the users would not have to experience such problems and frustrations.

But, are such examples sufficient to put pressure or form a need to make changes regarding the design practices? The following could guide us to the answer.

2.9.1. The new reality – Statistics and critical changes – Drivers:

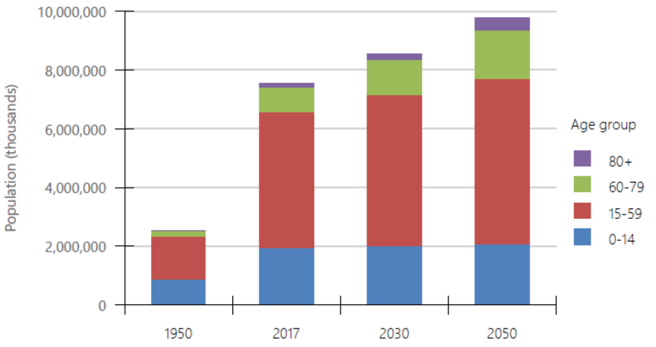
- **Ageing:** In essence, we are living through a dramatic change in the age structure of populations around the world (Coleman, R.: 1999, p. 159) – demographic changes, especially in the developed world. Now, the world is very different than before; people are living longer (Story, M.: 1998, p. 13). Longer life expectancies and a reduced birth rate are resulting in an increased proportion of older people within the adult population (Coleman, R.: 2007, Intro., p. 1-20). There are various pointers, such as governments and UN statistics that suggest the world is graying at a noticeable rate (Kurniawan, S.: 2009, p. 8-1).

  Globally, by 2050, the number of the world's older population aged 60+ is expected to reach 21.3% (approx. 2.1 billion) compared with 12.7% (approx. 962 million) in 2017 and 8% (approx. 203 million) in 1950. Also by 2050, the number of the world's older population aged 80+ is expected to reach 4.3% (approx. 425 million) of the world population compared with 1.8% (approx. 137 million) in 2017 and 0.6% (approx. 137 million) in 1950. (UN: 2017, World Population Ageing 2017, Report, p.2 & UN: 2017, Profiles of Ageing 2017, World) – fig.2.11.

  In Germany, by 2050, the number of the older population aged 60+ is expected to reach 37.6% (approx. 29.8 million) compared with 28% (approx. 23 million) in 2017 and 14.5% (approx. 10 million) in 1950. Also by 2050, the number of the older population aged 80+ is expected to reach 13.3% (approx. 10.5 million) of the population compared with 6.3% (approx. 5.2 million) in 2017 and 1% (approx. 0.7 million) in 1950. (UN: 2017, Profiles of Ageing 2017, Germany) – fig. 2.12.

Population by age group (thousands)

Age	1950	2017	2030	2050
Total	2,536,275	7,550,262	8,551,199	9,771,823
0-14	868,845	1,956,906	2,025,226	2,082,813
15-59	1,465,095	4,631,093	5,119,868	5,608,551
60-64	73,520	305,503	409,161	534,395
65-69	55,195	237,956	340,749	450,306
70-74	37,431	164,194	260,703	367,095
75-79	21,923	117,328	193,624	303,936
80+	14,265	137,282	201,868	424,728
80-84	9,619	76,700	113,860	220,011
85-89	3,468	40,190	56,175	128,117
90-94	946	15,975	24,036	55,982
95-99	197	3,932	6,643	17,454
100+	35	485	1,153	3,165



Population by age group (percentage)

Age	1950	2017	2030	2050
0-14	34.3	25.9	23.7	21.3
15-59	57.8	61.3	59.9	57.4
60+	8.0	12.7	16.4	21.3
65+	5.1	8.7	11.7	15.8
80+	0.6	1.8	2.4	4.3

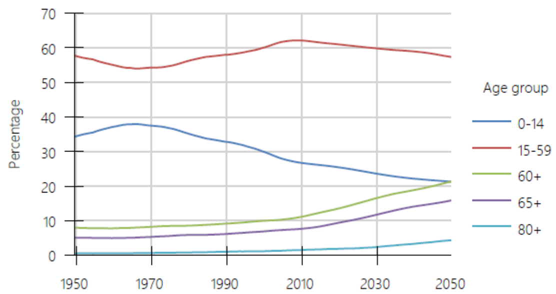
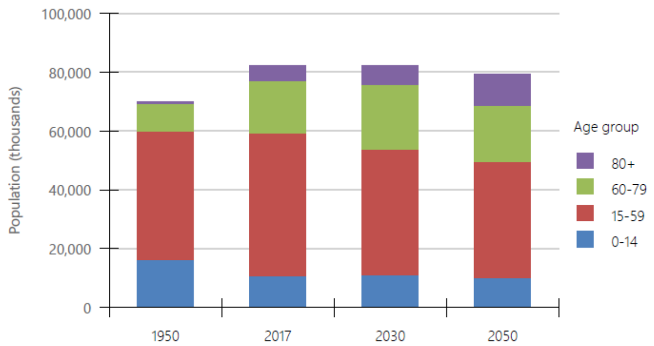


Fig. 2.11: Profiles of ageing in the world (UN: 2017, Profiles of Ageing 2017, World).

Population by age group (thousands)

Age	1950	2017	2030	2050
Total	69,966	82,114	82,187	79,238
0-14	16,116	10,736	11,185	10,217
15-59	43,699	48,382	42,487	39,200
60-64	3,388	5,380	6,497	5,506
65-69	2,726	4,390	6,368	5,020
70-74	2,122	3,999	5,251	4,421
75-79	1,225	4,081	4,102	4,337
80+	692	5,146	6,297	10,537
80-84	448	2,843	2,881	4,803
85-89	189	1,468	2,071	3,565
90-94	48	672	1,098	1,664
95-99	6	149	220	448
100+	0	14	26	56



Population by age group (percentage)

Age	1950	2017	2030	2050
0-14	23.0	13.1	13.6	12.9
15-59	62.5	58.9	51.7	49.5
60+	14.5	28.0	34.7	37.6
65+	9.7	21.5	26.8	30.7
80+	1.0	6.3	7.7	13.3

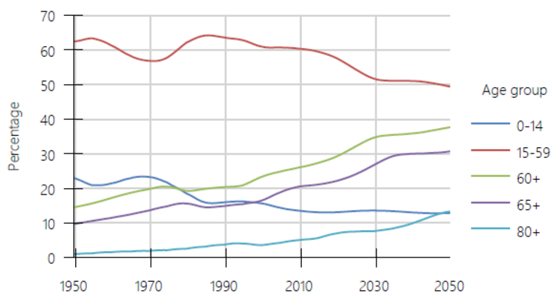


Fig. 2.12: Profiles of ageing in Germany (UN: 2017, Profiles of Ageing 2017, Germany).

The United Nations Population Division periodically publishes population estimates and projections by country and world region. Its publications have shown that *population ageing is an international phenomenon*.

> *Although the process of population ageing is most advanced in Europe and in Northern America, where more than one person in five was aged 60 or over in 2017, the populations of other regions are growing older as well. In 2050, older persons are expected to account for 35% of the population in Europe, 28% in Northern America, 25% in Latin America and the Caribbean, 24% in Asia, 23% in Oceania and 9% in Africa.* (UN: 2017, World Population Ageing 2017, Highlights, p.1)

Although older adults form a small proportion in some countries, they are a large number that can't be underestimated. For example, in Egypt, the older adults aged 60+ form 7.9% (approx. 7.7 million) and the older population aged 80+ form 0.8% (approx. 0.78 million) of the Egyptian population in 2017 (UN: 2017, Profiles of Ageing 2017, Egypt).

These demographic changes result in a population that is older and more disabled than at any time in history; longer lifespans and higher survival rates for people with severe injuries and illnesses mean more people are living with disabilities now than many realize, and the number is increasing (Story, M.: 1998, p. 7, 3).

- **Impairment:** Now, potential consumers of design who may be functionally limited by impairment are increasing at a dramatic rate (ibid.: p. 13). An estimated 253 million people live with *vision impairment*: 36 million are blind and 217 million have moderate to severe vision impair -ment (Bourne, R.R.A.: 2017 and WHO: 2017, Blindness and visual impairment). 81% of people who are blind or have moderate or severe vision impairment are aged 50 years and above (ibid.). Also, over 5% of the world's population – around 466 million people – has disabling *hearing loss*, and 34 million of these are children (WHO: 2018, Deafness and hearing loss). It's estimated that by 2050 over 900 million people – 1 in every 10 people – will have disabling hearing loss (ibid.). Approximately 33% of people aged 65+ are affected by disabling hearing loss (ibid.).

It is estimated that between 13.3 and 16.1 million individuals aged 18+ in the USA are living with cognitive impairment; they are afflicted with common brain disorders and diseases (FCA: 2013)[1]. The U.S. Census Bureau's 1999: 2004 American Community Survey estimated that

[1] See also, cdc.gov/aging/pdf/cognitive_impairment/cogimp_poilicy_final.pdf

10.6% (approx. 23.3 million) of the U.S. adult (16+) population are living with *motor impairment* (i.e. with a condition that substantially limits walking, climbing stairs, reaching, lifting or carrying). (USCB: 2004 and Keates, S.: 2009, p. 5-2)

- **Sex:** With the remarkable *change in gender roles*[1], especially in developed countries, it has become common to find women doing tasks previously confined to men. For example, women work as truck drivers, taxi drivers, construction workers, pilots and police officers. The same could be encountered for men; they now work as babysitters, nurses, male midwives, kindergarten teachers and childcare workers. Also, men are becoming more involved with raising their children and sharing in household activities and tasks.
- **Cline:** With the diverse reasons for immigration, changes in the racial composition of populations are evident; many societies have been considered as *multi-racial societies* – most societies consist of individuals who belong to many clines (with different clinal traits). Globally, there were an estimated 258 million international migrants in 2017; between 1990 and 2017, the number of international migrants worldwide rose by over 105 million; most of this increase occurred from 2005 to 2017, when some 5.6 million migrants have added annually (UN: 2017, International Migration Report 2017, p. 1)[2].

  International migrants are unevenly distributed across the globe: in 2017, over half (51%) of all international migrants in the world were living in only 10 countries (ibid.: p. 6). The largest number of migrants resided in the USA, which hosted 49.8 million migrants in 2017 (19% of the world's total); Saudi Arabia and Germany hosted the 2nd and 3rd largest numbers (12.2 million each) – fig. 2.13 (ibid.: p. 6). For example, at the end of 2017, there were approx. 700.000 Syrians in Germany (Statista: 2017).
- **Abnormality of body measures:** In a world whose population exceeded 7.55 billion in 2017 (UN: 2017, Profiles of Ageing 2017, World), people with abnormal body measures – not within the common ranges or around the averages of the human physical and functional body measures – even if they are a small proportion (globally or clinally), make up a large number of people that can't be underestimated. With regards to left-handers (lefties), worldwide,

[1] The 21st century has seen a shift in gender roles due to multiple factors such as new family structures, education, media, and several others. Various groups, most notably the feminist movement, have led efforts to change aspects of prevailing gender roles that they believe are oppressive or inaccurate. Gender equality allows gender roles to become less distinct.

[2] See also, un.org/en/development/desa/population/migration/index.shtml

statistics suggest that approx. 13% of the world population is left-handed[1]; this means that nearly 1 billion persons are lefties.

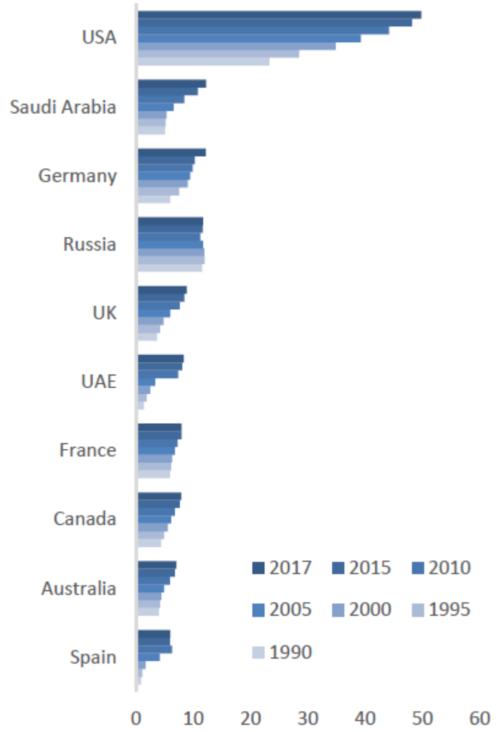


Fig. 2.13: Countries hosting the largest number of international migrants, 1990: 2017 (UN: 2017, International Migration Report 2017, p. 6).

- **Lifestyle and nutrition:** In our current globalized world, changes in the lifestyle and nutrition of a single person are becoming common. In turn, this leads to changes in the distribution of biological characteristics (physical and physiological measures – anthropometric data) in the population.
- **Skill level:** In an era of rapid technological development, designed things are becoming more complex (Cassim, J.: 2007, Why Inclusive Design? p. 16). This makes people fall within a wide and uneven spectrum of skills (Ashok, M.: 2009, p. 4-6).
- **Ideology-related personal factors[2]:** With the diverse reasons for immigration, many societies and some countries and continents have been considered *multi-ethnic societies* (Myerson, J.: 2007, p. 27) – they consist of individuals who belong to many cultures. Also, in our current globalized world in which navigation across borders has become easier, and 'improvements in communication technology and particularly the rise of the Internet have figuratively shrunk

[1] statisticbrain.com/left-handed-statistics/

[2] They include cultural identity and character style.

the world and broken down borders, allowing for a free exchange of information and cultures' (McDermott, C.: 2007, p. 120), it's common to find indigenous people of a society or country adopting different cultures from their original one – they are sometimes countercultures. In addition, naturally, the personal character styles of people vary widely.

- **Empowerment-related personal factors:** Empowering personal characteristics vary widely – see section 3. Features of empowering personal factors including income and wealth, social status, political power, geographical location, knowledge, education, and profession vary from person to person.

- **The performance environment:** In a globalized world where most designed things have moved across borders, there's a sheer increase in the number of diverse performance environments in which a copy of a designed thing may be used. Nowadays, countless copies of a designed thing are being used by different users in different performance environments. While the size of potential customer markets is growing, the *diversity* of the consumer base is expanding at the same time to include differences (Story, M.: 1998, p. 12) in *potential* contexts – *end-users and performance environments.*

- **People's expectations:** Now, the world is very different than 100 years ago. Along with the above-mentioned realities, the quest for independence and equal rights has grown as well (ibid.). Whatever their category, people aspire to active participation within the mainstream of society (Myerson, J.: 2007, p. 28). Over time, there has been a shift in focus, from a perspective where the individual is seen as an asset that should contribute to society by performing work that is suitable for the individual's characteristics and capabilities[1], to a perspective where the individual is seen as someone who should have the right to participate in all parts of society irrespectively of his/her capabilities – i.e. '*from a perspective where individual characteristics and capabilities determined what the individual could (and should) do, to a perspective where everyone is supposed to be able to do everything by adapting the tools used*' (Persson, H.: 2014, p. 511, 513). Now, the person's position and role in society are renegotiable and re-definable depending on the individuals' aspirations.

Now, marginalized groups – whatever their category – are no longer an insignificant or silent minority (Story, M.: 1998, p. 13), especially with the *increase of international and govern-*

[1] People's roles and tasks are set according to their characteristics and capabilities.

mental legislations of discrimination[1] (Coleman, R.: 2007, The Business Case, p.38). For example, older and impaired people are becoming more assertive in their demands – in particular that they shouldn't be excluded from the mainstream of society (ibid.). Increasingly, older people reject the dependency and institutionalisation that were the norm for much of the last century, and are beginning to assert themselves as consumers who control significant amounts of disposable income and as participants in the knowledge economy who have valuable expertise and experience to offer in the workplace (Myerson, J.: 2007, p. 28). Also now, users of assistive technology demand that products be designed with concern for their impact on the image, as well as the function, of the user (Story, M.: 1998, p. 13).

In addition, some designed things are expected to be appropriate for use at the office or school, at home, in the community, and on vacation. (ibid.)

- There's a major change in the way different people are viewed in society. The tendency to refer to such people, e.g. the elderly and impaired, as if they form distinct groups outside the mainstream is today being challenged by a growing trend to recognize them. Now, ageing and impairment are recognized as something we will all experience as part of the normal course of life. (Myerson, J.: 2007, p. 28)

[1] For example, important UN documents addressing discrimination include (Wikipedia: Discrimination):

- The Universal Declaration of Human Rights is a declaration adopted by the United Nations General Assembly on 10 December 1948. It states that: Everyone is entitled to all the rights and freedoms outlined in it, without distinction of any kind, such as race, colour, sex, language, religion, political or other opinions, national or social origin, property, birth or another status.
- The International Convention on the Elimination of All Forms of Racial Discrimination (ICERD) is a UN convention. The Convention commits its members to the elimination of racial discrimination. It was entered into force on 4 January 1969.
- The Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) is an international treaty adopted in 1979 by the United Nations General Assembly. It came into force on 3 September 1981.
- The Convention on the Rights of Persons with Disabilities is an international human rights instrument treaty of the UN. Parties to the Convention are required to promote, protect, and ensure the full enjoyment of human rights by persons with disabilities and ensure that they enjoy full equality under the law. The text came into force on 3 May 2008.

2.9.2. Answering the questions:

Now, it's acceptable to answer the following 2 questions:

- **The 1st research question:** What are the causes related to design practices that make design correlates with the *unsustainability state of the world* regarding the *social inequity in meeting human needs*? Or what don't design practices consider and contribute to the *unsustainability state of the world* regarding *social inequity in meeting human needs*?
- **The question of section 2.9:** Is there an urgent need to change?

Considering the above-mentioned statistics and critical changes – the *inevitable new reality* – and referring to the aforementioned examples of *design exclusion regarding usability* in section 2.8, that can be invoked, it's clear that the human needs haven't been satisfied collectively on an acceptable level. Some basic needs of many people's segments of the world haven't been included in the scope of design practice; many designed things can't be *equally usable* and simultaneously experienced by the largest number of people. This informs that: first, the past and current economic, social and political systems have failed to adopt and/or create suitable types of satisfiers for this task; second, design practices serving under such systems haven't collectively provided what empower what fully and consistently meet people's needs on an acceptable level, or haven't collectively actualized the *noble social role* of design on an acceptable level. Thus, design has failed to nurture the process of equally meeting fundamental human needs on an acceptable level.

What is so often evident is that the actors haven't deeply considered the *diversity of dynamic usage contexts* (*users and performance environments*), because if they had, then the users wouldn't have to experience such problems and frustrations. Actually, design as a means has lost more of its social responsibility regarding *equity in meeting human needs* (the 2nd area of SRD). This failure to deeply consider the *dynamic diversity of people's usage contexts* in design practices sets a *correlation between the existing design state and the unsustainability state of the world* regarding *social inequity in meeting human needs*.

This justifies us to acknowledge that *unequal design practices* or *not deeply considering the dynamic diversity of people's contexts characteristics in design practices* is a verified cause behind the phenomenon '*the correlation between design and the unsustainability state of the world*' specifically '*social inequity in meeting human needs*'. *Thus, we can acknowledge the validity of the 2 proposed research hypotheses answering the 1st research question.*

To regain *social* relevance, there has to be an effort to refine the *design theory* to address *equal usability* considerations and also to identify and address the weaknesses and failures of design in this area. We need to redefine design from a commercially driven discipline to one that's used to improve the quality of life for everyone[1]. This requires a *revolution in design* to reach the excluded segments.

Considering the above-mentioned statistics and critical changes – the *inevitable new reality* – and referring to the aforementioned examples of *design exclusion regarding usability* in section 2.8, where the design considerations of *equal usability* have been previously overlooked, it's now impossible for design practitioners to continue to ignore them for various reasons, incl. economic ones. For example, older persons are increasingly becoming the dominant group of customers of a variety of designed things (both in terms of number and buying power) (Kurniawan, S.: 2009, p. 8-1). It becomes imperative to avoid treating all contexts as the same. The inevitable new reality deserves to be recognized and respected and poses a radical challenge to design. It increases the need to *make changes in design practices* so that design is sensitive to the *dynamic diversity of potential usage contexts* (users and performance environments) – regarding the physical interaction; i.e. things must be designed to serve well in the potential diverse contexts. Such a new reality offers a rationale for a required new design approach for *countering design exclusion regarding usability*. Thus, the approach '*design for equal usability*' is here proposed as a part of the general approach '*equitable design*'. It isn't a new design style; it's a logical response to the previous set of critical changes which form a tsunami competing for attention in a world still newly awakened to a shared responsibility for sustainability.

Here, it would be unreasonable, inefficient and ineffective to call for a *revolution in design* to ensure *equal usability* without an accompanying *revolution in business* through which design is often practiced.

[1] theindexproject.org/about

2.10. 'Design for equal usability' as a part of 'equitable design':

For countering *design exclusion regarding usability*, we have to base our designs on the principle of inclusion; so, the *design for equal usability* approach is proposed as a part of the *equitable design* approach. It refers to design based on a *context-sensitive* approach considering equity with regard to usability. The main goal of *design for equal usability* is to ensure that all people find what is usable to achieve a specific task or satisfy a specific human need regardless of the contextual factors (personal & environmental factors) related to the use relation. It aims that no one should be excluded because of his/her use context characteristics related to the use relation. It aims to ensure and extend comfortable use for the widest possible people; i.e. to prevent the exclusion regarding usability while at the same time increasing the quality and usability of designed things. So, it's a design approach that places the *dynamic diversity regarding use* at the heart of the design process.

At the heart of *design for equal usability* lies a deeply human- and environment-sensitive focus on human and environmental dynamic diversity in all their aspects related to the use relation respectively. Dynamic diversity concerns not only users but also performance environments which are continuously developing and diversifying – see sections 2.5 and 2.6. The real contexts are much more complex and must be considered from wider perspectives. The related line of reasoning is that since both users and performance environments are dynamic and diverse, thus, end-users have different usability requirements, and it's necessary to consider all of them in a *context-sensitive* design process.

So, *design for equal usability* is a more *holistic* approach seeking to consider the dynamic diversity of use contexts resulting from the effects of all contextual factors related to the use relation; in turn, this requires considering a *wider range of requirements*.

Transcending the traditional view of usability targeted toward the *elusive average case*, *design for equal usability* embraces theoretical, methodological, and empirical research that addresses usability in any context of use – i.e. by any end-user, anywhere and at any time – or addresses the new demands for the dynamic diversity of use contexts for ensuring equally high-quality usage interactions. This conceptual approach is shifting the actors' interest from the *elusive average case* to real contexts of use. It challenges the conventional approach of designing according to the average user and the standard environment, and seeks to provide a design foundation for more *equally usable design*. In general, the designed things have been normally designed for the average user and then adapted to the needs of people who are more or less far from average (Emiliani, P.: 2009, p. 2-1) – see section 2.8.1. The same could be mentioned regarding designing in accordance with the standard environment at the expense of the performance one – see section 2.8.2.

Traditional efforts (*reactive actions*) to provide usability for excluded users were based on the adaptation of designed things originally developed for the average case, and/or the adaption of performance environments. The *reactive actions* for inclusion may be undertaken by the excluded themselves, those being responsible for this exclusion, or other parties seeking to protect the excluded. Due to the essentially reactive nature of such efforts, their costs, their possible negative effects on functionality (Emiliani, P.: 2009, p. 2-6, 2-7) and their outcomes stigmatizing such people, and with the current dramatic changes in the world – see section 2.9.1, the need for *systematic* and *proactive approaches* for equal usability have emerged – starting from *barrier-free design* and ending with such a more holistic proposed approach.

The need for this approach is creating new challenges and opportunities for developing the mainstream designed things considering equal usability. In theory, this may appear to be a formidable challenge, but investing energy into achieving equal usability is a valuable effort. The challenge inherent in such an approach should be taken as an inspiration for *good design* and not an obstacle. Actually, designing everything to be equally usable for everyone under all conditions is virtually impossible with a *one-solution-fits-all* – rarely can every designed thing achieve global comfortable use with a single solution (Ashok, M.: 2009, p. 4-8; Marcus, A.: 2009, p. 9-4; Vanderheiden, G.: 2009, p. 3- 13); even if so, is it practical or feasible? So, *design for equal usability* adopts the *one-solution-fits-all* as the main path and supports it with other paths to ensure *inclusiveness* and *practicality*.

Paths: Here, a set of *7 proposed paths* could be followed by those who practice and manage design to avoid *design exclusion regarding usability*:

1. Reduce the level of ability (the body ability levels and skill level) required to use the designed thing as much as possible – reduce the designed thing demands – to achieve usability for an extended range of users, in a variety of situations; this expresses the *one-solution-fits-all*; e.g.

powered doors with sensors; smooth ground-level entrances without stairs; cars with electric sliding doors; low-floor buses; lever handles for opening doors rather than twisting knobs; components that don't require tight grasping, pinching or twisting the wrist; light switches with large flat panels rather than small toggle switches, buttons and other controls that can be distinguished by touch, use of meaningful icons with text labels; labels in large print on equipment control buttons; auditory output redundant with information on visual displays; visual output redundant with information in auditory output; instruction that presents material both orally and visually; and 4-wheeled suitcases – see also, the examples of OXO Good Grips and Whirlwind Roughrider wheelchair in section 2.11.8.1.

2. Make the designed thing adaptable or adjustable (add adaptive or flexible features to the same designed thing); e.g. low-floor buses with expandable ramps, kneeling buses, Toyota cars[1], volume controls on auditory output, choice of language on speech output, web pages that provide alternative text to describe images, and a museum that allows visitors to choose to listen to or read descriptions – see also, the examples of Lindstrom Rx cutters, Toyota Sienna Auto Access Seat and adjustable office chairs and desks in section 2.11.8.1.

3. Offer the designed thing in other modified versions; e.g. clothes and shoes in different sizes – see also the examples of STABILO EASYsharpener, STABILO Easy start family and Hultafors hammers in section 2.11.8.1.

4. Make the designed thing compatible with related common add-ons – incl. *assistive aids*[2]; e.g. beds compatible with bed canes; the possibility of adding different grab bars near the toilet;

---

[1] Toyota has already made its cars ready for adaptation from the start. 'If the buyer would like to make some changes in the driving environment, such as changing the accelerator from using it with the foot to using it with the hand, a standard gizmo can be bought and easily installed. They have made most of the controls in the car replaceable. This means that if a user wishes to change the steering, it is easy to replace the steering wheel with something else as long it is following the Toyota standard. This way the increased accessibility potential comes with a minimum of extra costs, something that makes the design more equitable' (Persson, H.: 2014, p. 508, 509).

[2] Assistive aids are designed things used with mainstream designed things to make them more accessible and usable by individuals with particular impairments. They are especially important for individuals with severe or multiple impairments, where building sufficient accessibility into or usability for mainstream designed things isn't practical. So, there are individuals who won't be able to operate mainstream designed things directly without the need for some type of assistive aids. (Vanderheiden, G.: 2009, p. 3- 4, 3- 13)

The label, 'assistive technology', was applied to devices for personal use created specifically to enhance the physical, sensory and cognitive abilities of people with disabilities and to help them function more independently in environments oblivious to their needs (Story, M.: 1998, p. 10).

low-floor buses providing interior space for strollers, bicycles, wheelchairs and walkers[1]; and tactile paving guiding people with a blind stick. Regarding compatibility with assistive aids, this would help make designed things more customizable, and ensure that assistive aids are thought of in the original design and integrated into the design and appearance of such things to reduce costs and eliminate stigma (Cassim, J.: 2007, Why Inclusive Design? p. 19).

5. Develop supplements for the designed thing to fit more contexts regarding usability; e.g. bed canes, booster car seat, car assist footrest and external fans for laptops.
6. Offer other *alternative solutions* for equivalent usability; e.g. the ramp adjacent to stairs, the elevator adjacent to escalators and the voice recognition software alternative to regular key-board entry.
7. As a last resort, *improve the context characteristics* (related to use) of the underserved to avoid as much as possible customizing impractical special things for them; e.g. improving the literacy level of illiterates and who have low literacy levels in some societies by tech hardware and communication companies enables such people to catch up with a lot of such companies technological programmes, applications and devices without needing to customize special ones for them, providing programmes that uplift the end-users' skill levels required to use a designed thing; and participating in the development of assistive aids supporting body abilities and designed to be used with a related designed thing to make it more usable by individuals with particular impairments.

The 7 paths can lead to diversity-supportive design and prove that equally usable design is a realistic goal. Anyway, to achieve this goal, choosing the suitable path or paths will have to be established upon a careful trade-off among them based on functional and economic criteria.

While the first 6 paths could be classified as a *context-fit* path, the 7th could be classified as a *context-improve* path. The *context-fit* path adopts solutions offered to match the use-related characteristics of the contexts of the underserved (disabled, elderly, novice users, etc.) to include them. The *context-improve* path adopts solutions offered to improve such character-istics to uplift the use abilities of the underserved. A simple example is to improve the literacy

[1] Low-floor buses usually include an area without seating (or seating that folds up) next to at least one of the doors, where wheelchairs, walkers, strollers/prams, and where allowed even bicycles, can be parked.

level of illiterates and those who have low literacy levels in some societies – via efforts could be offered by communication and tech hardware companies. This builds a good solution to illiteracy and such people may enjoy a technology-based life and can improve their position in the class pyramid. So, this would contribute to social and economic development. Besides the purpose of their creation, the mainstream technological programmes, applications and devices should be designed with another purpose in mind: to eliminate illiteracy.

Improving and preventing deterioration of the personal and environmental characteristics of people's contexts may uplift their capabilities and facilitate working on meeting their needs. Rather than working on fitting the contexts characteristics for making designed things fit with the people's capabilities to meet their needs, sometimes, it may be practical and better to improve the contexts characteristics.

While the 1st path (*one-solution-fits-all*) doesn't imply a separate, specialized or segregated solution, the 2nd to 6th show increasing levels of *customization*. While *segregated proactive* solutions weren't practical in the past, now, considering the current dramatic changes in the world – see section 2.9.1 – and downstream problems and their costly reactive solutions – see section 2.11.8, *segregated proactive solutions may become more practical because they are arranged to come as an integrated part of the system*.

Dynamic diversity requires diversity: *Design for equal usability* doesn't suggest that it's always possible to design a single solution to address the same needs of all people[1]. Instead, it guides an appropriate design response to the diversity and dynamism of use contexts via following the aforementioned paths; i.e. via developing a *family* of designed things or derivatives to provide the best possible people coverage.

Also, it shouldn't be conceived as an effort to advance a single solution for everybody, but as a *context-sensitive approach* providing a family of solutions that can automatically address the possible range of contexts. Consequently, the outcome of the design process isn't intended to be a singular design, but a design space populated with appropriate alternatives, together with the rationale underlying each alternative, that is, the specific *use context characteristics* for which each alternative has been designed. (Emiliani, P.: 2009, p. 2-8, 2-17)

[1] inclusivedesigntoolkit.com/whatis/whatis.html

It's a process: Following alternative design decisions leads to diversity in the final design outcomes. Because of this, it may be more appropriate to consider the *design for equal usability* approach as a *process*, rather than an *outcome*. Such a process can foster innovation and improve design and it's likely to deliver a thoughtful design space populated with appropriate alternatives (designed things) which ensure that all people find what is usable for participating in a specific life activity or satisfying a specific human need – see successful case studies in section 2.11.8.1.

Equal opportunities: *Design for equal usability* works on enabling equitable use and equitable active participation of all people in human activities. It gives independence to all people and enables them to have equal opportunities to participate in every aspect of society; i.e. it helps liberate and enable people. It promotes the inclusion of all people in all life activities.

Definition: *Design for equal usability* can be defined as:

- ''the design of mainstream things to be usable by as many people as possible even if through diverse solutions when inevitable.''
- ''the design that ensures usability for the widest possible end-users even if through diverse solutions.''
- ''the design that ensures that all people find what is useable for satisfying a specific human need regardless of their different contexts.''

Thus, *equally usable design is design that considers the full range of personal and environmental dynamic diversity of potential interaction contexts with respect to the use relation whether through a single solution when possible or diverse solutions when not.*

Localization: The *design for equal usability* approach and its proposed paths point out that *localization* should be attendant *in some way* for equal usability; paths *not* following the *one-solution-fits-all* path (2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th} and differently 7^{th} paths) depend on localizing the solutions to fit specific contexts and similar (by *considering or/and improving* local conditions, reality or capabilities regarding use). Thus such an approach could combine *generalization* and *customization* in a design space. *Design for equal usability* adopts the *one-solution-fits-all* as the main path and supports it with other paths to ensure *inclusiveness* and *practicality*. Following such paths in praxis with considering small-scale local businesses and local culture, and/or depending on local people, businesses, technologies, crafts, designed things, resources and materials, increases the attendance of *localization*.

Also, such an approach takes us from dominance of ideas to adjustment of ideas on the local levels, and acknowledgment of the value of the local, the diverse and the particular. This would seem to be at odds with the dominant systems of corporations, communications and manufacturing that approach the *elusive average case* model. For this, actors seeking to address the consequences of unequal *usability*, need a clear sense of what they are trying to achieve (sensitivity to context) and how to go about it (the process of achievement).

Here, the process of localizing a designed thing refers to considering the dynamic diversity of use-related characteristics of specific contexts or markets to enable their people to find what is effectively and equally usable. To achieve effective localization of a designed thing, it's necessary to identify groups with similar contexts within larger groups of the population (Ashok, M.: 2009, p. 4-8).

An example showing a high level of *localization* of a designed thing for a specific social group would be customizing a technological application for villagers in the Egyptian countryside. Here, literacy issues would be a major concern when dealing with members of certain rural communities. Furthermore, because the users reside in a village, their exposure to technology is likely extremely low. Complex features would be lost on a group that would struggle with basic keyboard functionality. Perhaps in such a situation, *speech-recognition software* would benefit the users more than regular keyboard entries. What appears usable to someone in the USA may be unusable to another one residing in a small village in the Egyptian countryside. Understanding users is, as always, vital to the design and development of technological applications for a global audience. This example presents a complex challenge for designing technology for users who have minimal exposure to technology and low literacy levels. (ibid.: p. 4-8, 4-9)

SRD: By adopting the *design for equal usability* approach, design as a means would regain more of its lost social responsibility regarding *equity in meeting human needs* (the 2nd area of SRD model). Through this process aiming to achieve *equity in meeting human needs*, design may play another social role through approaching the *context-improve* path – i.e. through improving the underserved people's context characteristics related to use to uplift their use abilities which facilitates working on meeting their needs. In this, design embraces the new recently emerged area of *SRD* concerned with tackling the complexity of the most pressing issues, such as illiteracy, poor healthcare and poor infrastructure, being actually *inhibitors* for features of the contextual factors that negatively affect the use-related characteristics of people's contexts that should be considered for meeting their human needs. Improving and preventing the deterioration of such characteristics are actual resistance to the impacts of these *wicked problems*.

This *holistic, innovative and socially responsible* approach constitutes a *creative and ethical challenge* for the design, business and decision-making communities. It completely places the *responsibility* on people who practice, commission or manage design to ensure equity regarding usability. The failure to achieve this requires *interventions* to ensure usability for those who are excluded.

Proactiveness: *Design for equal usability* is a *proactive approach* aiming to avoid exclusion regarding usability, avoid downstream problems resulting from exclusion, minimize the need for reactive actions (posterior adaptations or specialized designs), and deliver designed things that can be tailored for use by the widest possible end-users. Accordingly, this entails a forward-looking *proactive attitude* toward shaping new generations of things rather than short-/medium-term *interventions* on the present and market situation (Stephanidis, C.: 2009, Universal access and design, p. 1-2).

Required conscious efforts: *Design for equal usability* may be defined as a general framework catering for purposeful, conscious and systematic effort to *proactively* apply principles and methods, and employ appropriate tools to develop equally usable design, thus avoiding the need for reactive actions (ibid.). Without conscious effort, it's very easy to exclude by design (Cassim, J.: 2007, Why Inclusive Design? p. 17, 18). To this end, the use-related characteristics of the broadest potential end-users' contexts must be taken into account throughout the entire development life cycle of new designed things as early as possible (from the early design phases – conception, to design and release). Under this perspective, *design for equal usability* affects the entire development life cycle of designed things.

To reach a successful and cost-effective realization of this vision, it's critical to ensure that suitable methods and techniques of a designed thing development are available. Traditional development processes, targeted toward the *elusive average case*, are clearly inappropriate for addressing the new demands for *equal usability*. Classic design methods are suboptimal since they can't accommodate diversity and dynamism. Working in this area should concentrate on design and development frameworks, methodologies and tools that help deeply recognize and support the *design for equal usability* approach, and integrate the consideration of dynamic diversity of use contexts throughout all development phases. (Stephanidis, C.: 2009, Universal access and design, p. 1-5)

The best practices regarding *design for equal usability* will be those focusing on the *context-sensitive* and *process-oriented* nature of design. Main efforts in this direction are concerned with the identification and study of various non-mainstream target user groups (e.g. elderly, disabled, novice users, etc.), as well as of their requirements for interaction; the identification and study of various potential performance environments, as well as of their requirements for interaction; and the identification, design and development of appropriate frameworks, methods, techniques and tools that help deeply address the real needs according to the *design for equal usability* approach (ibid.: p. 1-4).

Promoting the message: To achieve *equally usable design* requires considering the dynamic diversity of the potential use contexts in the design process; in turn, this entails that all actors (people who *practice*, *commission* or *manage* design) should acknowledge such an approach, i.e. acknowledge that diversity is the one true thing that contexts have in common and dynamism is an inevitable matter. Considering diversity aims to avoid the problems of excluding some potential end-users, and considering dynamism aims to avoid future problems of excluding end-users who are already included. So, inspiring and nurturing a new generation of actors will be crucial for the future – for more inclusiveness and tolerance, and the most effective way of doing this is to encourage them to think about others and future or dynamic diversity rather than following unconsciously the *elusive average case* model (Cassim, J.: 2007, Towards inclusion, p. 232).

Acknowledging and adopting the dynamic diversity regarding the use relation by all actors requires promoting the *equally usable design message* within the design, business and decision-making communities; i.e. it requires raising the awareness of all actors for changing their mindsets/attitudes to help adopt the *design for equal usability* approach. This could be achievable via providing sufficient reliable relevant knowledge (leading to real requirements), developing empathy towards the non-mainstream potential cases, and eliminating the fears and doubts about such an approach. Here, some fundamental keys could be proposed for raising awareness needed to promote the *equally usable design message* within the 3 communities or for those whom dynamic diversity regarding the use relation isn't on their radar:

- Building up the relevant literature
- Actively involving diverse potential end-users in the design process
- Simulating the non-mainstream potential contextual characteristics – Simulation
- Working at the margins (outside the range of average case)
- Going deeply into other disciplines related to the use relation – Interdisciplinary studies
- Varying the design team members – Multi-characteristics design team
- Creating realistic scenarios considering diverse potential use contexts – Scenarios
- Eliminating the fears – Motivations

These keys could raise the actors' awareness and help them improve the *majority's quality of life* through *equally usable design* that promotes independence and social inclusion. To work well in raising awareness of all actors toward the *design for equal usability* approach, these keys suitable supportive frameworks and methods, and consequently appropriate techniques and tools – according to the *aimed actor*. The focus in the following section will be the rationale for these keys**,** and the positive impact that they can have on the aimed actors and the final design outputs.

2.11. How to promote 'design for equal usability'? – Fundamental keys:

2.11.1. Building up the relevant literature:

There are many ways to get information regarding any approach. The most common ones are *literature searches*, talking with people, focus groups, personal interviews, and surveys. A literature search involves reviewing all publications (readily available materials). These materials may be texts, images, illustrations, audio/visual contents or audio-visual contents. These are published in the form of books, booklets, journals, articles, conferences publications, periodic reports, databases, presentations, videos, audio outcomes and any other published materials.[1]

These materials may be published as a hard copy or online. Nowadays, there's a preference for literature searches over the web (web-based information) because it's current, relevant, linked and open-ended and is always the fastest (Cassim, J.: 2007, Empowering designers and users, p. 108). Compared to the other ways, the literature search is often the cheapest, fastest and preliminary way of getting information.

Reliable publications being relevant to *design for equal usability* would be a main source of the required knowledge for the design, business and decision-making communities (for the actors); in turn, this may raise their awareness and change their mindsets/attitudes helping adopt the *design for equal usability* approach. Also, such publications may develop empathy towards the *excluded end-users*, and eliminate the fears and doubts about this approach; in turn, this may change the actors' mindsets and be a powerful driver for them to consider needs beyond their own immediate experience based on *self-observation* or/and the *dominant paradigm of design* (based on the *elusive average case*). According to the aimed actor, information could be presented via many ways, such as curriculums, courses, work-shops, seminars, symposiums, conferences, vocational training, coaching, periodicals, etc.

Building up the literature of *design for equal usability* approach for promoting it within the design, business and decision-making communities, isn't an easy mission. The nature of this approach based on equity and dynamic diversity requires countless, different complex information from various directions to form coherent literature. Also, some of this infor-

[1] statpac.com/surveys/research-methods.htm

mation should be constantly updated; such as statistical data about the distribution of the biological (physical and physiological) characteristics/measures in the population – anthropometric data.

Mainly, the literature content of the *design for equal usability* approach should cover the user-designed thing relation of use (facts – usability, dynamic diversity); the *why, what and how* of *design for equal usability* approach; and the *how* of promoting its message within the design, business and decision-making communities. This literature should include:

- Anatomy of the use relation[1]
  - The human body abilities (the macroscopic and microscopic physical measures and the physiological measures) and their related phenomena such as sound and light
  - The contextual factors (personal and environmental factors) and their direct and indirect effects on the user's ability of using a designed thing or on the 3 concepts of the use relation
- Dynamic diversity
- Design exclusion regarding the use relation
- Drivers (the new reality – statistics and critical changes) beyond the need to *design for equal usability* approach – section 2.9.1. They offer a rationale for the required new design approach aiming to counter *design exclusion regarding usability*. These drivers increase the need to make changes in design practices so that design is responsive to the dynamic diversity of the potential contexts.
- Reliable updated data and information about the potential end-users
  - Reliable updated statistical data about the demography of the potential end-users according to the *different related personal factors*. National, regional and global statistics would be important and useful. Here, updating is a critical matter due to the continuous demographic changes.
  - Reliable updated statistical data about the distribution of the personal characteristics related to the body[2] in the potential end-users (the spread of body capabilities across the

[1] It requires going deeply into other disciplines related to the use relation.

[2] – biological (physical and physiological) measures – human body abilities database or anthropometric data

target group). National, regional and global statistics would be important and useful. Here, updating is a critical matter due to the continuous demographic changes and the changeability of these characteristics for each person.

- Reliable updated design guidelines and standards regarding usability (ergonomics) for the typical and not-so-typical *characteristics related to the body or skill* of potential users – not-so-typical characteristics such as of impaired and older persons. Here, updating is a critical matter due to the continuous changes in relative technologies.

- Reliable updated data and information about the potential performance environments
  - Reliable updated statistical data about the demography of the potential performance environments according to *the different related environmental factors* – national, regional and global statistics would be important and useful. Here, updating is a critical matter due to the continuous demographic changes.
  - Reliable updated design guidelines and standards regarding usability (environmental ergonomics) for the typical and not-so-typical *physical characteristics* of potential performance environments. Here, updating is a critical matter due to the continuous changes in relative technologies.
- What is *design for equal usability*?
- Ways/paths of making designed things equally usable or avoiding design exclusion regarding usability – examples of equally usable designed things adopting these paths
- The origin of *design for equal usability* approach and the similar proactive approaches
- Fundamental keys of putting *design for equal usability* on the actors' radar or promoting the *equally usable design* message within the design, business and decision-making communities
- Frameworks, methods, techniques & tools developed and would be developed for achieving the fundamental keys promoting *design for equal usability* message within the design, business and decision-making communities – examples
- Guidelines for managing the adoption of or change to *equally usable design* in the business policy
- Successful examples of *equally usable designed things* on the design and business level
- Others

Any material belonging to the above-mentioned proposed points could form an effective stone in building the literature of *design for equal usability* approach. The importance level of any point varies according to the aimed actors to whom this point is directed. For example, while materials regarding the ageing population and its impact on the marketplace are of utmost importance to be directed to business management teams and decision-makers, they aren't of the same importance to be directed *in detail* to the design community. Also, while materials regarding the macroscopic and microscopic physical measures and physiological measures are highly important to be directed to the design community, they aren't of the same importance to be directed to business and decision-making communities.

The quality of actors' decisions regarding equal usability depends on the availability of comprehensive and good data – especially updated statistics. We should be well aware of the limitations of currently available statistical data serving the *design for equal usability* approach. An immediate challenge is to first design, and then undertake – at least, truly representative surveys on the national level covering the above-mentioned relative points to give the required data set that can underpin decisions serving for *equally usable outcomes*. However, the certainty that would come from this survey is likely to be a powerful driver for actors to acknowledge the *design for equal usability* approach.

It's worth mentioning that materials of similar proactive approaches such as *inclusive design*, *DfA* and *UD* would be of importance.

The following list provides a short list of useful resources covering or including some materials belonging to the previous points:

Books such as[1]:

- *Universal design handbook* (Preiser, W.: 2011)
- *Universal design handbook* (Preiser, W.: 2001)
- *The universal access handbook* (Stephanidis, C.: 2009, The universal access handbook)
- *The universal design file: designing for people of all ages and abilities* (Story, M.: 1998)
- *Design for inclusivity – A practical guide to accessible, innovative and user-centred design* (Coleman, R.: 2007, Design for Inclusivity)
- *Inclusive design: design for the whole population* (Clarkson, J.: 2003)
- *Countering design exclusion: An introduction to inclusive design* (Keates, S.: 2004)

[1] Full details of books are given in the references section

Journals such as:

- *Diversity in design: The journal of inclusive design education*
- *Applied ergonomics*
- *The design journal*
- *Design studies*

Publications and proceedings of conferences such as:

- The international conference *include*, the Helen Hamlyn Centre for Design at the RCA, www.rca.ac.uk/research-innovation/helen-hamlyn-centre/knowledge_exchange/include-conferences/
- *The international conference for universal design*, by the international association for universal design (IAUD), Japan, www.iaud.net/global/conference/
- The international conference on *design for inclusion*
- The international conference on *applied human factors and ergonomics* (AHFE)

Contents of websites such as:

- www.rca.ac.uk/research-innovation/helen-hamlyn-centre/ of the Helen Hamlyn Centre for Design at the RCA, London, UK
- www-edc.eng.cam.ac.uk/research/inclusivedesign/ of the inclusive design group at the Cambridge Engineering Design Centre, University of Cambridge, UK
- www.inclusivedesigntoolkit.com/ developed by the inclusive design group at the Cambridge Engineering Design Centre, University of Cambridge, UK
- https://humancentereddesign.org/ of the institute for human centered design (IHCD), Boston, US
- www.iaud.net/global/ of the IAUD, Japan
- www.universaldesign.com/
- https://projects.ncsu.edu/ncsu/design/cud/ of the Center for Universal Design (CUD), NC State University, US
- http://idea.ap.buffalo.edu/ of the Center for Inclusive Design and Environmental Access (IDeA), University at Buffalo, US
- https://idrc.ocadu.ca/ of the inclusive design research centre (IDRC) at the Ontario College of Art and Design University (OCAD U), Toronto, Canada
- www.designforall.org/ of the Design for All Foundation
- http://dfaeurope.eu/ of Design for All Europe
- https://data.worldbank.org/ of the World Bank (WB)
- https://data.worldbank.org/indicator of the WB
- https://shop.un.org/ of the UN publications

- www.undp.org/content/undp/en/home/ of the United Nations Development Programme (UNDP)
- www.who.int/publications/en/ of the WHO
- www.who.int/gho/en/ of the WHO
- www.statista.com/

Others:

- ISO 7250[1] – *Basic human body measurements for technological design*
- ISO 20282-1 – *Ease of operation of everyday products – part 1: Context of use and user characteristics*
- ISO/TS 20282-2 – *Usability of consumer products and products for public use – part 2: Summative test method*
- ISO 21542 – *Building construction – Accessibility and usability of the built environment*
- British Standard (BS) 7000-6[2] – *Guide to Managing Inclusive Design*

This isn't a complete list but provides a starting point for finding out more. It offers us a straightforward route map for getting preliminary information that may help establish the literature of *design for equal usability* approach. It contains resources that aim to inform actors with the perspective of dynamic diversity.

[1] ISO 7250 is a series of reports on body measurements. It consists of the following parts, under the general title *Basic human body measurements for technological design*: Part 1: 2008, *Body measurement definitions and landmarks*; Part 2: 2010, *Statistical summaries of body measurements from individual ISO populations*; and Part 3: 2013, *Worldwide and regional design ranges for use in ISO products standards*.

[2] British Standard (BS) 7000-6 is a comprehensive guide to managing *inclusive design*. It was published in February 2005 to help all organizations (private, public and not-for-profit (NFP)) evolve such a professional stance. It provides guidance at both organization and project levels. It provides the language and framework by which the design community can understand and respond to the needs of diverse users without offending or stigmatising them. The ultimate goal is to meet, as far as possible, the needs of the whole population through mainstream markets. The standard concentrates on the management, not the practice, of *inclusive design*. This reflects the fact that the outcomes of design projects are influenced far more by those who manage them than by the creative specialists involved. (Coleman, R.: 2007, The Business Case, p.41. 42)

2.11.2. Actively involving diverse potential end-users in the design process:

‘When assessing the ease of use of their design solutions, designers tend to use their *own personal and professional skills* to predict how users will interact with products and what type of difficulties they might encounter. This approach is often defined as *self-observation*. Whereas most designers might be skilful enough to predict a wide range of typical usability problems, an obvious shortcoming of this approach is the designers’ assumption that they can be representative of a wider and heterogeneous population’ (Cardoso, C.: 2007, p. 197). In addition, as has previously been clarified, problems of unequal usability resulting from following the models of the average user and standard environment are tangible realities. This has resulted in solutions that are difficult to use by a wide range of users, especially the elderly and impaired people (Cardoso, C.: 2012, abstract).

The *involvement of diverse potential end-users in the professionally guided design process as active actors* may contribute to avoiding the *problems of unequal usability*. In this process, the emphasis shifts to a more substantive and equal interaction between the *designer* and the *user*; this goes beyond the users’ passive participation or the users’ usual limited passive status as ergonomic test subjects who could highlight the functional failure of designed things to one where they become active facilitators in every stage of the design process (Cassim, J.: 2007, Empowering designers and users, p. 89, 91).

Initially, the *active participation of diverse potential end-users in the design process* can deeply illustrate the *variety* of users and their performance environments that a designed thing should be designed for and used in respectively. It helps realistically know about the contextual diversity regarding the use relation or the diversity of potential end-users’ characteristics and their performance environments characteristics, thus, to get realistic requirements of the wider population to develop a designed thing for equal usability. Engaging with *diverse potential end-users* including *non-mainstream* ones (but realistic – e.g. impaired[1], elderly, novice users), helps provide a focus for the design team and ensures that they may consider needs beyond their own immediate experience based on *self-observation* or/and following the *average case model*.

[1] – incl. the *critical* users having severe sensory, mobility or dexterity disabilities to ensure that the major ergonomic issues are covered.

Additionally, actively involving *non-mainstream end-users* in the design process may be very fruitful. Such people devise ingenious ways of overcoming the difficulties they experience routinely with the designed world – *regarding problems of use*. They are expert users as they always look beyond product features to detect potential problems; and as a result, thoroughly select their designed things. They can 'embody design questions that force the designers to think laterally and from first principles and ensure radical problem solving' (ibid.: p. 103). Regarding use, since *non-mainstream end-users* – especially the elderly and impaired – 'are most affected by the failure of design, a negative viewpoint can be transformed into an active critical awareness of alternatives and possible solutions that has enabled them to become *collaborators in the design process rather than mere spectators or critics*' (ibid.: p. 105). By active interaction with such users and acknowledging how they 'tackled everyday tasks from a different lateral perspective, designers would be confronted with *out-of-the-box* thinking in its purest form' (ibid.: p. 92).

The *active participation of diverse potential end-users* in the design process provides what design guidelines and standards can't provide[1]; in turn, the requirements of the acquired information may differ. Actually, end-users present the real scenarios of use based on their expected experience of using the proposed designed thing; this experience is based on their full awareness of their real characteristics and their performance environments characteristics related to the use relation.

This process may require spending time with users in their own environment, rather than working on a project abstractly in another space, it's another important part of the *participatory design (PD) process* (Chick, A.: 2011, p. 46). If you find yourself designing cars to be used as well in 3rd world countries from the comfort of a design zone in Volkswagen Group Future Center Europe, Potsdam, Brandenburg, Germany, you aren't aware of an important matter: the low quality of the open space planning services in such countries and its accompanying different behaviours of drivers and pedestrians.

[1] When designers engage *directly* with real people then there's a richness of information that can't be obtained through more indirect design research methods alone, valuable though these can be. For example, engaging with people having reduced body abilities gives the designer a more holistic portrait of them than can be supplied by reading body capabilities data alone.

This approach may be very fruitful and give completely new insights into the design process (Persson, H.: 2014, p. 510), thus contributing to helping designers consolidate conflicting data, eliminate impractical solutions, and focus on design directions that make sense in inclusive terms (Cassim, J.: 2007, Empowering designers and users, p. 103).

Also, it can be a major force towards raising awareness and changing attitudes of the design community regarding equity and inclusivity (regarding equal usability). It's an inspiring process and helps demystify, illuminate and importantly empathize. Additionally, end-users may suggest ideas and solutions which are valuable. The stimulus resulting from users' participation process may change the designers' learning curve and lead to creative thinking.

The rationale of involving *diverse potential end-users in the design process* is that this ensures that the final design outcome meets actual needs and requirements and is usable by its intended audience (Chick, A.: 2011, p. 46). In turn, this enhances and enables the lives of people of all use abilities (body and skill) and actively captures new or overlooked markets even for designed things where the saturation point would appear to have been reached long ago (Cassim, J.: 2007, Empowering designers and users, p. 89).

'Users are the real experts on themselves and their situation, so are encouraged to take a leading role in exploring potential solutions and opportunities' (Chick, A.: 2011, p. 48). 'The logic is simple, if you are designing a solution to a problem, why not involve those who know the problem best and are the experts in relation to that problem? Why not involve the users? .... the expertise does not reside solely with the design professionals but is also to be found in those whose interests are affected by the problem and its proposed solution' (ibid.: p. 46, 47). Problem definition is itself subjective as it originates from a point of view; therefore all stakeholders' points of view are equally knowledgeable whether they are experts, designers or other actors (Fuad-Luke, A.: 2009, p. 142).

Without shared visions only short-term solutions are possible and these are unlikely to be the most sustainable solutions; shared visions, reached through *collaborative processes* are most likely to deliver sustainable solutions of long-term value (Chick, A.: 2011, p. 47). So, people have to dialogue, agree on how to frame the problem and agree on goals and actions; then participation in design seems essential (Fuad-Luke, A.: 2009, p. 142).

2.11.2.1. The user-designer relationships:

Before 1980, the *user-designer relationship* seemed restricted to a quantitative approach based on measuring people's bodies and analyzing the usability of designed things in relationship to people's capabilities.

1. From designing for to designing with: Gradually, the passive role of users has been changed. 'Since the 1980s there has been a shift in attitude of certain business sectors towards its customers. The realization that the creative potential of these very same customers can help business create better services and products has encouraged the development of a range of methodologies to tap this potential' (Fuad-Luke, A.: 2009, p. 143). At the same time *user-centred design* (UCD) 'emerged as a tool to assist in new product development (NPD) where particular user groups would be invited or selected to participate in focus groups commenting on certain stages in the design process, especially the testing of early concepts and prototypes' (ibid.: p. 155). In 1999, John Thackara urged designers and design researchers to reposition their relationship with users from *designing for* to *designing with*[1], 'the language has shifted from designing for users to designing with users, from customer to user to co-creator' (Fuad-Luke, A.: 2009, p. 143).

2. Designing for, with or by people: In the *Include* 2007 conference, human factors expert Jane Fulton Suri presented a more advanced paradigm regarding *user-designer relationships*. 'This identified three types of relationship between designers and users: designing for people, in which designers study and consult people in their role as experts in the design process; designing with people, in which designers share the design process with people, who become active participants in the work; and designing by people, in which designers act as facilitators to enable people to make their own design decisions. Some design methods span all three types of relationships; others relate to just one'[2]. This new model indicates that design practices should seek to involve people actively in a *co-design* process.

The term *co-design* is used to denote *designing with others* (Fuad-Luke, A.: 2009, p. 147) or *actively involving all stakeholders* – such as employees, customers, citizens and end-users – in the design process (Chick, A.: 2011, p. 46). The co-design process isn't based merely on consultation with stakeholders but on their active participation (ibid.: p. 47). It 'offers an

[1] yankilee.com/wwwdesigningwithpeopleorg

[2] yankilee.com/wwwdesigningwithpeopleorg

opportunity for *multi-stakeholders* and *actors* to collectively define the context and problem and in doing so improve the chances of a design outcome being effective' (Fuad-Luke, A.: 2009, p. 147). It contests dominant hierarchically orientated top-down power structures; and attempts to democratize them by ensuring that *stakeholders* play a critical role in designing it (ibid.: p. 147, 148). This agrees with the new rules of networks, not hierarchies. However, co-design is an approach focused on processes and procedures of designing; it isn't a design style (Chick, A.: 2011, p. 46, 47). Also, it isn't simply about the application of methodologies to achieve a design result via the active involvement of stakeholders in the design process, it's about a mindset and attitude about people and a belief that everyone has something to offer the design process (Fuad-Luke, A.: 2009, p. 150). *Co-design* is a catch-all term to embrace approaches that encourage the participation of all stakeholders (ibid.: p. 147) – such as *PD*, *cooperative design* and *meta-design*.

Regarding *end-users as stakeholders*, the underlying premise of co-design is that it's an approach predicated on the concept that people *who ultimately use* a designed thing are entitled to have a valuable voice in determining how that thing is designed (Carroll, J.: 2006, p. 3). For some, this approach has a political dimension of user empowerment and design democratization (Chick, A.: 2011, p. 46).

This new style of user-designer partnership 'raises questions as to how best to integrate user interaction into the design process. Which users should be selected for which project and in what combination? When and at what point should they be involved and in what capacity if they are no longer merely to be used for ergonomic testing or the validation of design features?' (Cassim, J.: 2007, Empowering designers and users, p. 89)

Designing with end-users doesn't mean allowing them to design for themselves; the designer is still the controller of the process, but working more inclusively (Chick, A.: 2011, p. 47). Under the direction/instruction of the design professionals, the degree of participation required of the end-users is relevant to the context in hand (Fuad-Luke, A.: 2009, p. 156).

Designing with end-users may be very fruitful and give new insights into the design process, thus contributing to higher usability (Persson, H.: 2014, p. 510), and ensuring it for end-users' categories represented in the participation process. This requires ensuring that chosen participating users are truly representative of the target user population. Following the *average case model* in choosing the users actively involved in the design process will consequently lead to excluding the other potential end-users.

2.11.2.2. Positive indicators regarding active involvement of the non-mainstream end-users in the design process:

The involvement of real end-users during the design process is typically accepted as an essential approach to developing designed things that fulfill the needs and requirements of the *wider* population (Cardoso, C.: 2007, p. 197). There's evidence that the way the user is now involved in the design process is subtly changing (Fuad-Luke, A.: 2009, p. 147). Nowadays, several activities, websites, books, conferences and journals are fully dedicated in a whole or a part to participation approaches. The term *approach* is used here to denote a combination of elements of the underlying design philosophy, processes, methodologies and tools. The level to which these elements are developed does vary (ibid.: p. 147).

For example, there's a wide range of materials, techniques and methodologies to support participatory practice, some recently developed by the Helen Hamlyn Centre for Design at the RCA. For a long period of time, it launched the website *designingwithpeople.org* which presented resources that support a general shift in design practice from *designing for people* to *designing with people*[1]. It provided practical resources for working with real people.

In its *people* section, the website presented 10 real people – not fictional characters – fig 2.14. *They are real individuals with differing degrees of functional loss across the spectrum of capability*. They were selected in partnership with the Cambridge Engineering Design Centre under 5 categories – vision, hearing, mobility, dexterity and cognition – to represent a spectrum of capability across the UK population. They speak about their lives, their challenges, their relationship with design and the impact that poor design has on them. This seeks to give the designer a more holistic portrait of the individual than can be supplied by reading capability data alone. In the same section, for each category, case studies drawn from the Helen Hamlyn Centre for Design's portfolio provided further evidence of how people's needs and aspirations related to vision, hearing, mobility, dexterity and cognition can directly inspire better, more *equally usable design*.[2]

Also, in its *methods* section, such a website presented 20 research methods for inclusivity**,** most of which are participation methods helping designers engage with people in the design

[1] yankilee.com/wwwdesigningwithpeopleorg

[2] Ibid.

process; some methods are widely used; others represent emerging practice[1] – fig. 2.15.

To help choose the right methods for a project, in the same section, each method was explored and assessed from 4 different angles[2]:

- **Input and output:** Determine what you need to put in and what you'll get back. The *Methods Lab: User Research for Design* (Helen Hamlyn Centre – 1999) classified different methods according to the level of input in terms of the expertise, time, staffing and costs required and output in terms of what the designer gets out of it. Types of input are scored as low, medium or high.
- **Stage of the design process:** Select a method to suit the stage of the design process you are at. The UK Design Council's *double diamond* design process model (2005) maps the divergent and convergent aspects of the design process in 4 stages: *discover*, *define*, *develop* and *deliver*. Discover typically refers to the explore-and-understand stage of design; define to the stage of problem focus and definition; develop to the design-and-create stage; and deliver to the stage of final specification and production.
- **Designing for, with or by people:** Focus on your relationship with the people who will use your design. As has been mentioned, Jane Fulton Suri identified 3 types of user-designer relationships: *designing for people*, *designing with people*, and *designing by people*. Some design methods span all the 3 types; others relate to just one.
- **Type of interaction:** Select a method based on what type of activity is involved. IDEO (a global design company) identified 4 categories of interaction:

  - **Learn** – analyse information you've collected to identify patterns and insights
  - **Look** – observe people to discover what they do rather than what they say
  - **Ask** – elicit information relevant to your project
  - **Try** – create simulations to create empathy and evaluate proposed designs

  The website added an extra category:

  - **Imagine** – to reflect methods that embrace more fictional, futures-based and creative aspects of user interaction

[1] yankilee.com/wwwdesigningwithpeopleorg

[2] ibid.

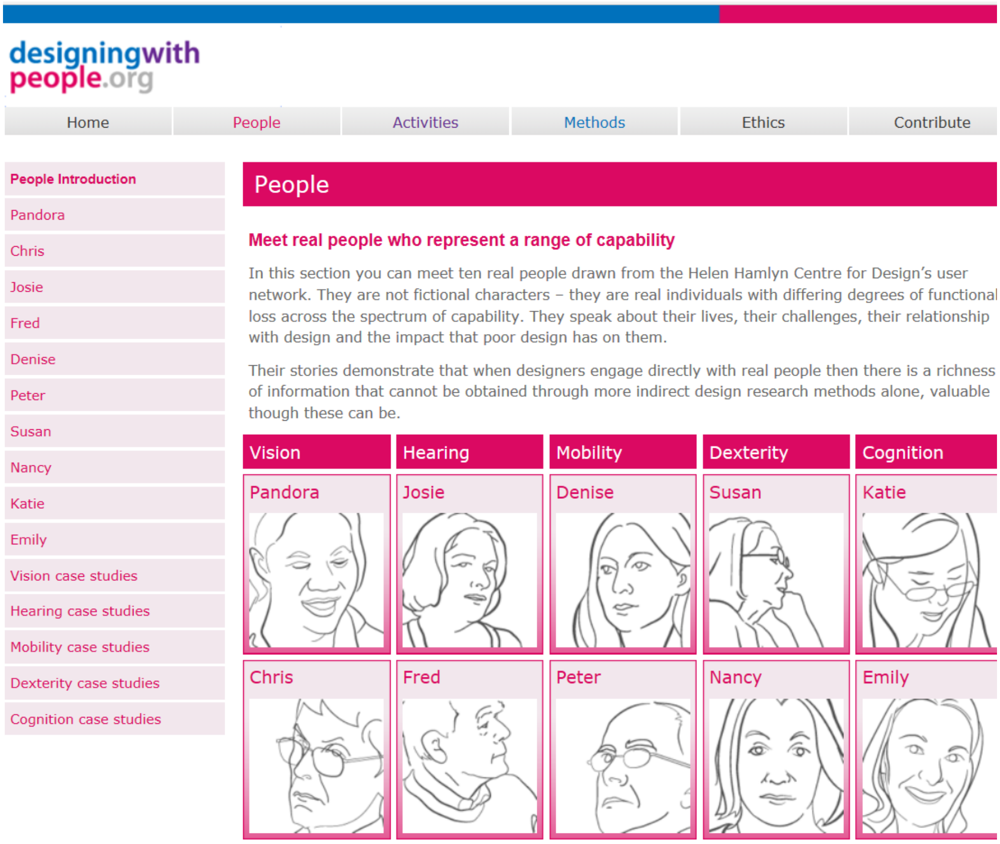


Fig. 2.14: The 10 real people with differing degrees of functional body loss on the website designingwithpeople.org. (yankilee.com/wwwdesigningwithpeopleorg)

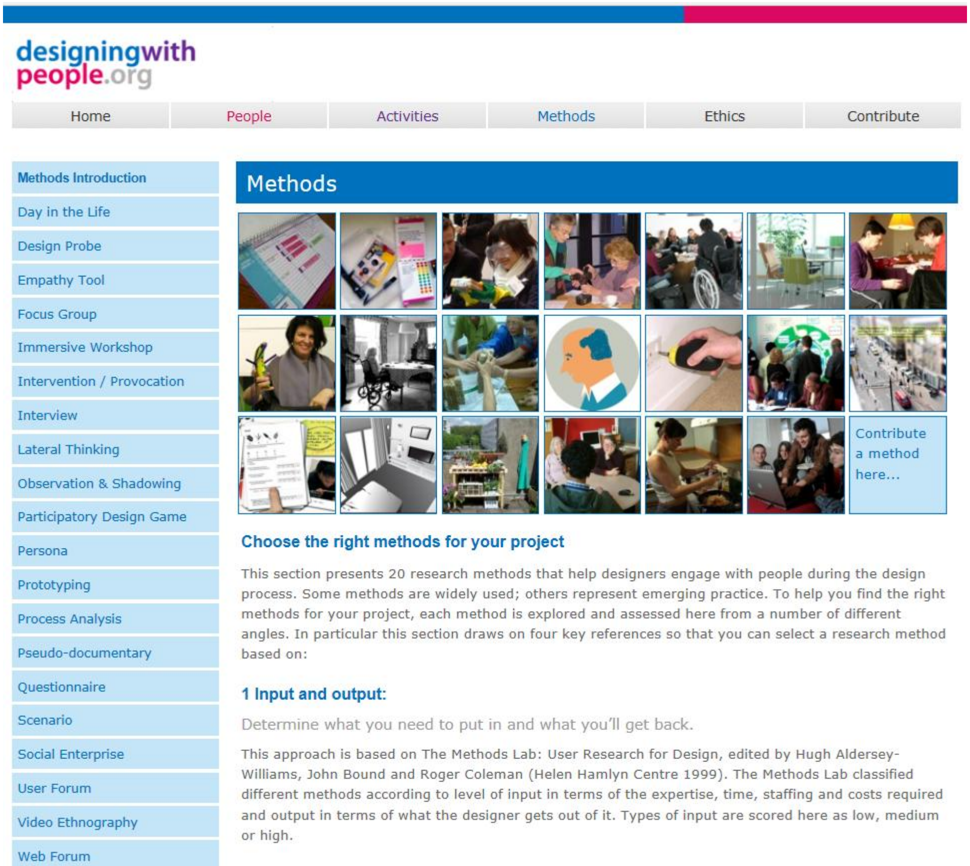


Fig. 2.15: The 20 research methods for inclusivity including the ones supporting participatory practice on the website designingwithpeople.org. (yankilee.com/wwwdesigningwithpeopleorg)

Each method in this section is also referenced with exemplar projects from the Helen Hamlyn Centre for Design and others in the field, which discuss how the method has been applied, and by background information and further reading.[1]

1. A case study: Factory Wears saucepan[2] – by Factory Design[3]

Here, there's a famous case study where diverse potential end-users were actively involved in the design process from the beginning.

Facts: 9 million people of all ages in the UK are affected by arthritis and every one of them needs to eat. Visually impaired cooks have a different set of issues, which relate more to safety and hygiene.

Initial proposal: *To design a saucepan that would meet the needs of a wide range of users.*

Challenge: *To create a saucepan that would transform the pain of those people's cooking experience to one where pleasure is uppermost and where safety and hygiene are assured.*

User input: *The team worked with users of different ages with severe arthritis and visual impairments who helped identify the areas most in need of attention.*

Key issues: Weight, handling, balance and drainage; the need for a multipurpose pan with a built-in colander; radius at the bottom too tight making cleaning difficult.

Design solutions: *The design team came up with a new footprint for the saucepan based on a universal pan size to accommodate different cooking methods. As the lead designer explained: 'We would look to develop a whole range to include all the capacity sizes that are familiar in the cookware audience. However, we specifically took the universal pan size because of the feedback from the user group, acknowledging that not many people want to use more than one pan at any one time. However, the physical size of the one we have designed is not as big as a normal frying pan and we wouldn't imagine having four pans of that size in the range.' The saucepan followed a traditional round shape but had conical sides for easy pouring and a large radius to facilitate cleaning. The body was made of aluminum body for lightness had a non-stick interior and a copper bottom to enhance cooking and cleaning. It also had an integrated aluminum colander for drainage and a two-part lid in transparent lightweight polycarbonate and aluminum with a hooped handle that is easy to lift. The lid upends to make stacking easy.*

---

[1] yankilee.com/wwwdesigningwithpeopleorg

[2] Cited from: designingwithpeople.rca.ac.uk/wp-content/uploads/CSdexterity-FactoryFactoryWares.pdf and Cassim, J.: 2007, Empowering designers and users, p. 96, 97

[3] Factory Design is an ideas-led design consultancy specializing in NPD, futures, transport, packaging, retail and environment design and strategic innovation.

A major feature of the new design is the ergonomic two-part long handle which radically changes the way in which the user holds the pan. With a fuller cross-section to assist gripping, it is angled downward for intuitive use and the oval comfort platform at the end shifts the weight of the pan to the arm from a single point at the wrist, ensuring greater balance, safety and less pain. The handle's main structural shroud is made of lightweight heat-resistant material overlaid with tactile foam-filled polyurethane to enhance gripping and the design team envisage that this could be used for a variety of other products besides the saucepans in the range. A secondary hooped handle on the opposite side of the pan allows for two-handed use which would spread the weight.

The final design was produced as a display prototype, has been widely exhibited and aroused interest from a major manufacturer. See fig. 2.16.

Critical user sessions in which users were examining existing cookware

Final design features - the ergonomic handle, secondary handle, thick base and lid

An inclusive outcome by designing with diverse potential end-users

Fig. 2.16: Factory Wares saucepan by Factory Design (designingwithpeople.rca.ac.uk/wp-content/uploads/CSdexterity-FactoryFactoryWares.pdf)

Designer comments: *When we first started, we had an open mind. We didn't go in with any pre-conceptions: we purposefully kicked off the project, taking on board the feedback from the user groups. We were looking at two-handed operation initially and realised that, to be truly inclusive, we had to make it as effective with one hand and then identify secondary use with two hands.*

***Gavin Thomson**, lead designer, Factory Design*

Factory Design won the 2003 Design Business Association (DBA) Inclusive Design Challenge[1] with its Factory Wares saucepan.

The design process was successful because it gave users of different ages with severe impairments the power to influence the design. By working together it was possible to identify the points most in need of attention in the early design that weren't compatible with the needs of a particular user group and resolve the problem without creating new problems for someone else. (Newell, A.: 2007, p. 129)

2. Other case studies: Many successful case studies have demonstrated the effectiveness of actively involving *diverse end-users* in the design process in achieving equally usable designed things – e.g. see Cassim, J.: 2007, *Empowering designers and users*, p. 92: 102. They have particularly proved the effectiveness of designing with *diverse potential end-users* in changing the attitudes of professional designers to equity and inclusiveness, largely because they have seen it as a way of driving innovation and creativity. Such case studies – especially involving real individuals with differing degrees of functional loss across the spectrum of capability – have demonstrated how this had empowered designers, how designers had been inspired by the process, how their information requirements differ, and how all had effectively interacted together at different stages of the design process. For those designers, direct user engagement is more effective than guidelines and regulations, which are perceived as inhibiting by the creative industries (Cassim, J.: 2007, Towards inclusion, p. 231). The advantage of guidelines and legislation/regulations is that they are readily available as publications (ibid.: p. 231).

[1] The DBA Inclusive Design Challenge – innovation through inclusive design – ran from 2000: 2010 and was an annual design competition with a difference. It illustrated the role design can play in enhancing the quality of life for older and disabled people and all of us. It was the collaboration between the DBA and the Helen Hamlyn Centre for Design; it was launched in 2000 as a creative response to developing the image of the disability aids and equipment sector. (rca.ac.uk/research-innovation/helen-hamlyn-centre/knowledge_exchange/challenge-workshops/dba-inclusive-design-challenge/)

3. On-track organizations: In UK, 'some good progress has been made in terms of engaging with older and disabled consumers and their representative organisations. The cerebral palsy charity SCOPE, the Royal National Institute for the Blind and the Royal National Institute for Deaf and Hard of Hearing, the car scheme for disabled people Motability, the Research Centre Institute for Consumer Affairs Ricability and the major age charities have all taken an interest in and played a part in promoting the value of inclusive design both to the communities they represent and nationally, to the general public.' (ibid.: p. 237)

2.11.2.3. Constraints:

Despite the *direct involvement of potential end-users* in the design process is a very useful and inspiring approach; it isn't always feasible in everyday design practice (Cardoso, C.: 2007, p. 197). The problems of *direct* engagement with end-users – especially *non-mainstream ones* – are many, from time, cost (budget), and logistical and sometimes ethical approval constraints to recruitment, and importantly in the process area itself – in how to do it (Cardoso, C.: 2012, abstract and Cassim, J.: 2007, Towards inclusion, p. 232). Such problems frequently prevent many designers and companies from having access to real end-users during the design process of the designed things they create (Cardoso, C.: 2012, abstract). In many cases, designers are forced to rely on their own experience or intuition to guide their assumptions about the end-users' and performance environments characteristics, which may well have little relationship to the true situation (Newell, A.: 2007, p. 114). In other cases, designers are forced to rely on data based on the *average case model* (the average user and standard environment models).

'Here there is a real need to develop either a nation-wide resource, or a network of local resources and expertise that designers and companies can tap into. There is an equivalent need in education at degree and post-graduate level, but also in schools.' (Cassim, J.: 2007, Towards inclusion, p. 232)

2.11.3. Simulating the non-mainstream potential contextual characteristics – Simulation:

The direct involvement of *really representative end-users* during the design process is typically accepted as an essential approach to developing designed things that fulfill the needs and requirements of the *wider* population (Cardoso, C.: 2007, p. 197). However, as has been previously mentioned, despite the importance of such a useful and inspiring approach, many constraints frequently prevent many design practitioners and companies from having access to real end-users during the design process of designed things they create (Cardoso, C.: 2012, abstract). The inability to involve end-users in the design process requires other alternatives to compensate somehow for this inability.

The implementation of more interactive and quick-to-use evaluation tools could potentially support design practitioners in performing more objective judgments during the design process (Cardoso, C.: 2007, p. 197). Simulation of the potential contextual characteristics (the different characteristics of potential end-users and performance environments) could be developed as an evaluation tool to temporarily represent potential contexts (end-users and their performance environments). Here, the aim of using simulators during the design process is to explore alternative and engaging ways of assessing the usability of designed things for the *wider* population (ibid.).

Simulating the characteristics of *non-mainstream end-users* (such as elderly and impaired people) and *non-mainstream performance environments* is to attract design practitioners' attention and *empathy* towards the excluded end-users from the ease of use of the mainstream designed things. It attracts attention to the total contextual factors related to the use relation, and helps learn about the different conditions and communicate the corresponding real-world issues to others. The use of *accurate* simulators aims to help designers experience and anticipate more objectively some of the usability problems that diverse end-users may encounter when interacting with a wide range of every day designed things, and thus, some of the disabilities they experience (ibid.). Such experiences show how design practices often ignore a large number of users, due to a lack of consideration of their contexts characteristics related to the use relation (ibid.: p. 198). It's particularly useful to uncover a series of unequal usability problems missed or not predicted by the designers during their *self-observation evaluations* (ibid.: p. 206), or uncovered during *trials of the unequally representative users*. Clearly, simulation can play an important role in raising awareness of the design practitioners and changing their mindsets/attitudes helping adopt the *design for equal usability* approach.

The harder a designed thing is to use while using a simulator, the more demand it places on the related body abilities and the more unusable it is. Conversely, if a designed thing remains comfortable to use while using such a simulator, then it's likely to be more comfortable for a broad range of users.[1]

The goal is that, by using accurate simulators, it's expected that the design practitioners will experience similar types of disabilities to the ones encountered by real users when interacting with their surroundings. The characteristic being simulated must be realistic, truly representtative in the potential contexts and capable of producing meaningful data. This involves a thorough simulation of the characteristic that real end-users or performance environments may exhibit, and ideally a direct mapping to the number of contexts with such a characteristic across the wider expected contexts. This understanding would potentially enable design practitioners to identify the most difficult features to use with the designed thing being assessed – when assessing user-designed thing interaction. (Cardoso, C.: 2007, p. 201)

Equally, the poor or imprecise simulation could lead design practitioners to assume that the simulated characteristic and the user's needs have been understood, which might result in inadequate assessment decisions (ibid.: p. 200). So, it would be necessary to have reliable data on how the simulated characteristic varies across the wider expected contexts. Such a complete and consistent data source requires careful and conscious efforts to obtain.

Simulation of the *body abilities losses* or the *biological characteristics of elderly and impaired people* is the most highlighted part in this field. The debate regarding this part may be suitable and representative for the required effort in the whole field.

[1] inclusivedesigntoolkit.com/tools_simulation/

2.11.3.1. Simulation of body abilities loss:

Simulating a reduction in vision, hearing, locomotion, dexterity or reaching and stretching abilities provides insight into the effect that a *body ability loss* has on using designed things[1]. This simulation aims to mimic the loss of body abilities to enable designers to uncover problems that they had previously overlooked when using their full able-bodied body abilities; the use of *body abilities loss simulators* helps designers experience and anticipate more objectively some of the usability problems that people, *exhibiting varying degrees of body abilities loss*, may encounter when interacting with a wide range of every day designed things and, consequently, into some of the disabilities they experience (Cardoso, C.: 2007, p. 197). Experiencing disabilities in such a tangible manner helps designers cope with the complexity of interpreting particular impairments, or trying to guess the physical challenges that older or impaired people may encounter (ibid.: p. 209). This kind of information is potentially easier to understand and to incorporate into design decisions (ibid.). This simulation is an economical and effective way of *raising awareness* about the effects of body abilities loss variation, which a large number of people may exhibit (ibid.: p. 199).

This simulation can build *empathy* with potential end-users having body abilities loss, change the way designers see things and make them look at life from a different angle, and be more mindful in the future. It helps compare and examine the usability of designed things (e.g. visual usability) and test a designed thing against our recommended benchmark, helping create *better* and *more equally usable design*.[2]

This simulation involves a person (usually able-bodied) wearing physical restrainers to feel the effects of different types of sensory and motor abilities loss. For instance, the wearer can use simulators that restrict movement in key parts of the body such as hands, elbows and knees. Also, earplugs and fogged spectacles can be used to simulate auditory and visual body abilities loss, respectively. (Cardoso, C.: 2007, p. 198)

The goal is that, by imposing particular body ability losses upon someone wearing an accurate simulator, it's expected that he/she will experience similar types of disabilities to the ones encountered by real users when interacting with their surroundings (ibid.: p. 201).

[1] inclusivedesigntoolkit.com/tools_simulation/

[2] inclusivedesigntoolkit.com/tools_simulation/

The type and the level of body ability loss being simulated must be *realistic*, *truly representative* in the potential end-users and capable of producing meaningful data. This involves a thorough simulation of the body ability losses that real end-users may exhibit, and ideally a direct mapping to the number of people with such characteristics across the potential end-users. This understanding would potentially enable designers to identify the most difficult features to use with the designed thing being assessed. (ibid.: p. 201)

It would be necessary to have reliable statistical data on how people's body abilities levels vary across the wider population. Although data sources comprising information about the impaired and elderly vary widely, such a complete and consistent statistical data source doesn't presently exist (ibid.).

Actually, several simulators of body abilities loss have been developed, ranging from simple to more sophisticated ones – see the following examples.

Examples of body abilities loss simulators:

1. **Simple examples:** One of the first body abilities loss simulations took place in the early 1980s and involved a group of architects wearing spectacles that reduced their visual capabilities while carrying out several tasks in everyday environments. Other more recent studies, especially in the field of design education, included simulation workshops where undergraduate students wore simple simulators to learn about the problems disabled people may experience when performing daily activities. The students tried to simulate, for instance, the effects of arthritic fingers by affixing buttons with tape on the knuckles of each finger. Visual capability loss was simulated by wearing blindfolds and fogged spectacles. Also, some experiments have been carried out involving students dressed up with ice hockey equipment, to simulate motor losses. (ibid.: p. 198, 199)

2. **Ford's Third Age Suit:** Ford Motor Company has created *empathy suits* to help vehicle engineers and designers build vehicles with special needs and limitations in mind; its Third Age suit simulates the limitations of people aged 50: 75[1]. It was developed by Ford Motor Co. and Loughborough University in the UK. Its 1st generation is made of coveralls with components (for instance, elbow and knee braces) sewn on, which attempt to simulate average

[1] agirlsguidetocars.com/fords-third-age-suit/

levels of body abilities loss that older adults may exhibit – as a way to better understand the needs of older drivers. These suits restrict movement in hinge points of the body, such as hands, elbows, knees and neck; additionally, earmuffs and yellow spectacles try to simulate hearing and visual body abilities losses, respectively – fig. 2.17[1]. The Third Age Suit has helped Ford's designers understand and anticipate the special driving requirements of their older customers. The technology has helped the automobile giant evolve many features, from different controls to push-button start to get the car going – which benefit all drivers now. This contributed to the commercial success of the Ford Focus, which has been described as easy to use, especially in terms of getting in and out of the car and operating the driving controls. (Cardoso, C.: 2007, p. 199)

Recently, Ford developed its 3rd generation of Third Age Suit. The suit can replicate nerve system degeneration using special gloves equipped with an electronic tremor generator[2]. Special goggles include lenses that can replicate visual impairments caused by different eye diseases[3]. Despite the usefulness and popularity of this simulation tool, recent studies recognized its limitations when considering the simulation of different levels of body abilities loss (Cardoso, C.: 2007, p. 199).

3. **Carlos Cardoso and John Clarkson's Simulation Toolkit:** (Cardoso, C.: 2007, p. 200: 205 & Cardoso, C.:2012)

About 14 years ago, Carlos Cardoso and John Clarkson presented a new simulation toolkit which was designed to enable a graduated simulation of different levels and combinations of body abilities losses. It consists of different components to simulate possible (but not all) body ability losses that, ultimately, could have led the designers to experience a series of real disabilities – fig. 2.18. The toolkit focuses on the simulation of visual, hearing, locomotion, reaching and stretching, and dexterity loss. This toolkit is made of modular components, each one addressing the simulation of body abilities loss in different parts of the body. The advantage of using modular components is that the assessors need only put on the parts of the toolkit that will enable them to affect specific body abilities. It consists of:

[1] Watch the Illustrative videos on: youtu.be/CEDF9ut7iCc and youtu.be/GpKwhSc4d68

[2] home.bt.com/tech-gadgets/ford-third-age-suit-11364044636148

[3] ibid.

Components of the Third Age Suit (wonderfulengineering.com/fords-age-suit-lets-you-experience-life-as-a-104-year-old-man/)

The Third Age Suit in action (wonderfulengineering.com/fords-age-suit-lets-you-experience-life-as-a-104-year-old-man/)

Fig. 2.17: Ford Third Age suit

The Third Age Suit in action (blog.4wheelonline.com/2015/06/15/fords-third-age-suit-aids-in-the-simulation-of-elderly-driving/)

- **Dexterity loss simulators:** The main impairment effect of the dexterity restrainers is to restrict the flexion of the fingers, for instance when trying to close the hand to pick up, manipulate and hold different objects. These simulators are composed of loose finger pockets that are placed at the back of each finger and that can be adjusted according to the size of the wearer's hand. Inside these finger pockets, increasing numbers of plastic strips can be inserted to augment the difficulties in closing the hand. This dexterity simulator also includes a wristband that limits movement of the wrist.
- **Reaching and stretching loss simulators:** This part of the toolkit limits arm movement in 2 main hinge points: the elbow and the shoulder. Flexion of the forearm is constrained by braces with inserted plastic strips placed at the back of the elbow. Shoulder flexion and extension are limited by adjustable straps that are connected to the waistband, which are also part of the locomotion restrainer. The adjustability of the shoulder movement enables the wearer to set the range of motion of both arms to specific angles. According to the level of severity to which these components are calibrated, the wearer will have difficulties, or even be prevented from, reaching at various heights, e.g. to pick up an object from a shelf in front of the body, at head level or above.
- **Locomotion loss simulators:** Since locomotion is related to the ability to walk and climb steps, but also to bending and straightening, these physical restrainers decrease both the wearer's ability to easily perform flexion of the legs but also to bend the torso. Knee braces with a metallic structure interfere with the ability to walk, climb steps and squat down, e.g. to pick something from the floor. A large waistband, with inserted vertical plastic strips, inhibits the action of bending forward and laterally.
- **Visual loss simulators:** The visual simulators comprise 9 pairs of spectacles that try to reproduce decreasing levels of visual acuity (the ability to perceive details presented with good colour contrast) through increasing the blurriness on the lenses. As the wearer puts on the different spectacles, the ability to recognize people and discriminate detail in the surroundings diminishes. The spectacles also affect the ability to perceive objects with poor colour contrast.
- **Hearing loss simulators:** These simulators include a set of earmuffs and earplugs. These devices affect mainly the ability to perceive different sound levels.

Dexterity loss simulators

Components of Carlos Cardoso and John Clarkson's Simulation Toolkit

Locomotion loss simulators

Reaching and stretching loss simulators

Fig. 2.18: Carlos Cardoso and John Clarkson's Simulation Toolkit (Cardoso, C.: 2007, p. 203: 205)

4. Cambridge simulation tools[1]**:** One of the leading design research groups in the UK at the University of Cambridge and its design group has developed some simulators for body abilities losses to be easily used in designed things development. These tools are:

- **Cambridge simulation gloves:** They provide insight into how limitations in fingers and thumb movement can affect designed things use. They simulate a reduction in the functional ability of the hands (simulate dexterity problems). They can be used to help people compare the demands placed by different designed things on dexterity. They use plastic strips to limit the strength and range of motion of the fingers and thumb. As an example, these gloves will make it much more difficult to use a knife and fork and grip small handles. See fig. 2.19 and 2.20.
- **Cambridge simulation glasses:** They provide insight into the effects of vision loss on product use. They simulate a general loss of the ability to see fine detail but don't represent any particular eye condition. The effects are representative of an inability to achieve the correct focus, reduced sensitivity of retinal cells, and problems with internal parts of the eye becoming cloudy. These effects typically occur with ageing and the majority of eye conditions, as well as not wearing the most appropriate corrective glasses. One pair of glasses simulates a mild loss of vision ability. More severe levels of impairment can be simulated by wearing multiple glasses on top of each other. The glasses have been designed to be thin and light -weight to enable this. Important issues not covered by these glasses include ensuring compatibility with visual aids and considering those with blind spots, tunnel vision, excessive glare sensitivity and colour blindness. See fig. 2.21 and 2.22.
- **Impairment simulator software:** It demonstrates the effects of vision and hearing impairments on image and sound files. The vision and hearing impairment simulator is an installable application that enables its user to: apply simulated vision impairment to own images, or any third-party programme running on a computer; export the results to an image file, ready to insert into a presentation; and listen to audio clips with simulated hearing impairment. See fig.2.23.

[1] inclusivedesigntoolkit.com/tools_simulation/

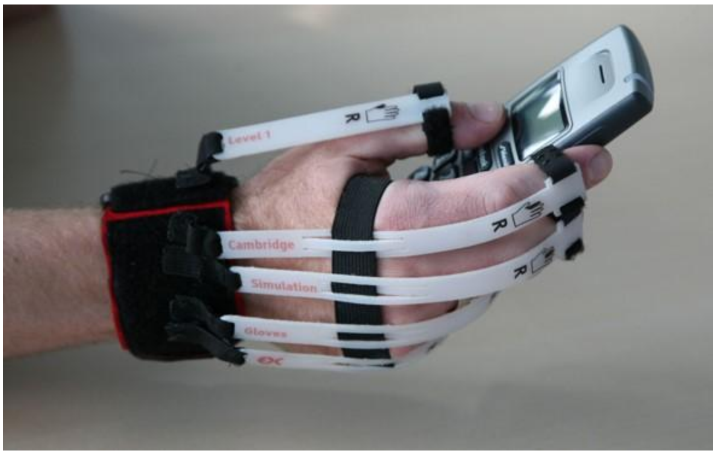


Fig. 2.19: Cambridge simulation gloves: The gloves limit the strength and range of movement of the fingers and thumb. (inclusivedesigntoolkit.com/tools_simulation/)

Fig. 2.20: Cambridge simulation gloves: The gloves can be used to compare the dexterity demands placed by different designed things. (inclusivedesigntoolkit.com/tools_simulation/)

Fig. 2.21: Cambridge simulation glasses: Different levels of impairment are simulated by wearing different numbers of glasses. (inclusivedesigntoolkit.com/tools_simulation/)

Fig. 2.22: Cambridge simulation glasses: Using the glasses to examine the visual clarity of 2 different kettles. (inclusivedesigntoolkit.com/tools_simulation/)

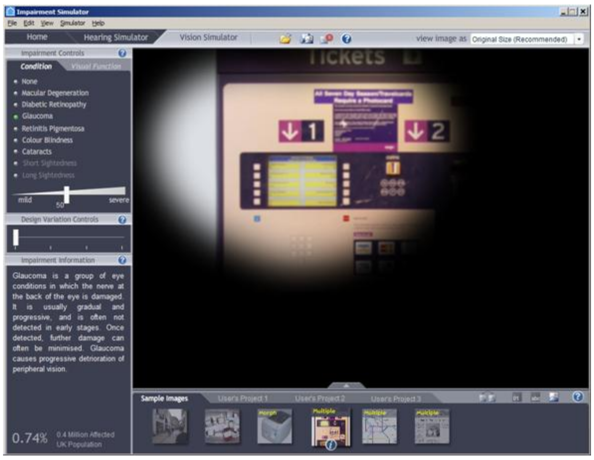


Fig. 2.23: Impairment simulator software: Showing the effect of moderate glaucoma. (inclusivedesigntoolkit.com/tools_simulation/)

2.11.3.2. Simulation as a supplementary assessment tool:

Here, simulation is suggested as a supplementary assessment tool/technique and not a replacement for the experience and benefits of working with real end-users (Cardoso, C.: 2007, p. 200). Any simulation can't convey the whole reality. Considering the simulation of a body ability loss, it can't convey all the effects of such a loss. For example, simulators that restrict the movement of hand fingers don't simulate other common effects such as pain, tremors, loss of tactile sensitivity and changes to the shape of the hand that occur with ageing. As an example, using a touchscreen keyboard on a mobile phone remains relatively easy with such simulators, but is particularly difficult for people with tremors[1]. Also, any simulation of a body ability loss doesn't enable designers to fully understand the consequences of being constantly with such a loss; people who exhibit a real body ability loss may have lived with that problem for a long time and may have developed alternative strategies for interacting with their surroundings, which designers would probably not predict even if using very accurate simulators (Cardoso, C.: 2007, p. 200). Therefore, these simulators are intended to be used in combination with other tools as part of a holistic evaluation[2].

So, simulators should be used *cautiously*. Using simulation as the only method of assessing the *ease of use* of a design thing could lead designers to overlook other important aspects of the interaction or miss certain design shortcomings that could have been uncovered during typical self-observation evaluations, or even more importantly during user trials (Cardoso, C.: 2007, p. 207). However, designers shouldn't rely *exclusively* on what the simulators enable them to experience, but rather supplement the usefulness of this tool with other assessment techniques (ibid.: p. 208). Considering the results from many tools will increase the chances of uncovering a wider range of *design problems regarding unequal usability*.

[1] inclusivedesigntoolkit.com/tools_simulation/

[2] inclusivedesigntoolkit.com/tools_simulation/

2.11.4. Working at the margins (outside the range of average case):

There will be a continuing and important need to work at the remaining margins outside the range of average case – whatever the relative contextual factor – where the usability challenges are the greatest (Cassim, J.: 2007, Towards inclusion, p. 230). Without continuous work at the remaining margins, there's unlikely to be a stream of innovations that will deliver the highest level of usability in the future (Cassim, J.: 2007, Why Inclusive Design? p. 19). Considering the *equal usability* in the design process results in designed things that could have an *added value* for those already included/served – now and in the future when their contextual characteristics related to use may change. Design improvements aiming at the inclusion of *those outside the average* – such as elderly and impaired people, novices, and people in non -standardized performance environments hindering ease of use – can offer real benefits to the *served average*; in turn, outcomes of such improvements can achieve market advantages.

There's a good reason to believe that innovations in this area will deliver important usability gains in the future (Cassim, J.: 2007, Towards inclusion, p. 230). Several designed things have been directed to serve the elderly and impaired and have been becoming mainstream things offering real benefits to young able-bodied people (Cassim, J.: 2007, Why Inclusive Design? p. 15). Some designed things have started as assistive devices and have been becoming mainstream products, e.g. kitchen utensils with thick grips popularized by Oxo International in their Good Grips line[1] (Story, M.: 1998, p. 11); also, remote controls, foot-operated tip-top bins, hands-free interfaces and predictive text technology were first developed as *aids* for people with special needs and are now ubiquitous (Cassim, J.: 2007, Why Inclusive Design? p. 15). Actually, designing for *those outside the average* can result in things that work better for everyone or bring about advantages for all citizens.

[1] – see p. 199: 202

2.11.5. Going deeply into other disciplines related to the use relation – Interdisciplinary work:

Depending on and believing in the unique ability of design to operate across disciplines and access the required knowledge and methods particular to each and harness them for the task at hand – for making a particular solution effective (Marshall, T.: 2008, Discipline, p. 134, 135), the study proposes 2 different kinds of *design permeations* in other disciplines to reach unrecognized knowledge about how deep the dynamic diversity of contexts related to the use relation is, in turn, this promotes the *equally usable design* message within the design community.

The debate on contextual factors and usability has demonstrated the relation between design and other disciplines such as anatomy, physiology, psychology and sociology. Such disciplines are key sources of knowledge supporting design disciplines. Achieving *equally usable design* requires *going deeply into* such disciplines via depending on *interdisciplinary* modes of working, studying, and knowing, *without needing to redraw or dissolve the boundaries between them and design*. This is via searching for deeper knowledge, resorting to professsionals of such disciplines or working in a multi-professional work team – designers may be members of teams that include other professionals such as biologists, physiologists, psychologists and social workers. The team works collaboratively to assess a problem and different team members give their experienced inputs as needed. The aim is to have more and effective knowledge – e.g. the dynamic diversity of physiological human measures – to serve the aim of *raising awareness* toward the dynamic diversity of contexts related to the use relation.

> M. Powell Lawton[1] *describes a research project for the elderly that sought to learn about the deficiencies in the home environment and the way people cope with them. A social worker, an architect, a psychologist, and an occupational therapist visited the homes of fifty highly impaired older people who were managing to live alone. One of the team's findings was that many of the people they observed had set up "control centers" in an area of their living room that allowed them to view the front door and, through a window, the street. The nearby placement of a telephone, radio, and television also enabled them to have social contact with the outside world. Additionally, on a table within reach were medicine, food, reading material, and other items of use. If a product designer had been on this intervention team, he or she would no doubt have been*

[1] – from (Lawton M.: 1990)

> *stimulated to create products that could serve the low-mobility needs of this older population.* (Margolin, V.: 2002)

Another required kind of *design permeation* in other disciplines is one based on *interdisciplinary* modes of working, studying, and knowing, but requires *redrawing or dissolving the boundaries between design and them*. Here, *interdisciplinary studies* involve the combination of 2 or more academic disciplines or schools of thought into one activity. It's about creating something by thinking across traditional boundaries. For example, an *interdisciplinary study* between design and the field of *assistive technology* (rehabilitation engineering) could be valuable in promoting the *equally usable design* message within the design community.

The potential benefit of permeation with each other is exciting but mostly untapped (Story, M.: 1998, p. 11). In principle, 'commercial designers have much to learn from rehabilitation technologists familiar with the ergonomics of disability and aging' (ibid.: p. 11). Also, for widely usable designed things, permeation in this field and collaborations between designers and those working in assistive aids would help make such things more customizable, and ensure that assistive aids are thought of in the original design and integrated into the design and appearance of such things to reduce costs and eliminate stigma (Cassim, J.: 2007, Why Inclusive Design? p. 19). In addition, as has previously been mentioned, some designed things were first developed as *aids* for people with special needs and are now mainstream things (ibid.: p. 15). So, importantly, we need to see the field of assistive technology as a precursor to *equally usable* solutions in the mainstream and invest in it accordingly (Cassim, J.: 2007, Towards inclusion, p. 230). On the other side, 'rehabilitation technologists and their clients can benefit from designers' expertise in creating products and environments that are functional, safe, attractive, and marketable for a wide diversity of users' (Story, M.: 1998, p. 11). Successful results of permeations between design and assistive technology will change the traditional ways of using technology for the social inclusion of people with disabilities regarding usability. Instead of serving *reactive approaches* via assistive aids, technology should switch to *proactive approaches* whereby assistive technology is no longer the technological solution for inclusion, but one of its components (Emiliani, P.: 2009, p. 2-17).

Finally, both above-mentioned kinds of permeation require new collaborative and integrated forms of practice, which in turn requires new methods and tools ensuring valuable permeations.

2.11.6. Varying the design team members – Multi-characteristics design team:

When possible, varying the design team members to include individuals from *diverse contexts related to the use relation* (men and women, youth and elderly, impaired and able -bodied, natives and foreigners, etc.), could help acknowledge diversity. Varying the design team members forms a good platform for raising their awareness about the dynamic diversity of contexts. It's a reliable tool for assessing the *equal usability* of designed things they create. Firstly, every member could closely recognize diversity through interacting with the other members having diverse human characteristics related to the use relation and affiliated with diverse environmental characteristics related to the use relation. Secondly, as users, the diverse members of the team ensure more successful assessment decisions based on their own experiences with the designed thing being assessed. The most successful effort in this area is increasing the representation of women within the design profession. Feminist movements have been credited with this.

> *Feminists in the 1970s and 80s pointed out that minorities and larger groups without sufficient purchasing power could not have their needs met or contribute to design policy. This was because architecture, products and technologies were largely produced by white, middle-class men from the Western World for consumers who could afford to buy. Feminists aimed to increase the representation of women within the design profession, and were involved in specific user-led and resident-led projects (Rothschild, 1999). In the UK, feminism failed to radically alter the design of products, environments and communications. In Germany and Austria, however, women's rights were integrated into the practices of local authorities and governments, resulting in the design of housing and public spaces to meet the needs of women and family-friendly policies (Stummvoll and Davey, 2003).* (Davey, C.: 2005)

While big design entities with a big design team have the chance to vary their team members, small ones haven't. Also, not all *contextual characteristics related to the use relation* could be represented in a design team, e.g. people with severe visual or cognitive impairment couldn't join the design team as professionals.

2.11.7. Creating realistic scenarios considering diverse potential use contexts – Scenarios:

Here, scenarios are storylines that explore the *potential contexts of use* or how potential end-users might interact with a particular design in their performance environments. Scenarios are imaginative and may be presented as texts, illustrated storyboards, plays and videos. Jane Fulton Suri and Matthew March (2000) describe the advantages and pitfalls of using scenarios and where they're best placed in the design process (Suri, J. F.: 2000).

The creation of an appropriate and representative set of scenarios considering mainstream and non-mainstream (but realistic) potential use contexts and considering the effect of time on them in the design brief, can illustrate the *dynamic variety of end-users and performance environments* that a designed thing should be designed for and used in respectively, or the *dynamic variety of contexts characteristics related to use*. While scenarios built on the existing reality represent a horizontal expansion via including people excluded from easy use, scenarios built on the effect of time on contexts characteristics related to use represent a vertical expansion via predicting the realistic future of contexts. So, every proposed scenario needs to show a real contextual awareness of the present and future. 'The fact that the future can never be viewed or fully predicted does not negate our responsibility to identify possibilities that beg precautionary action' (Fry, T.: 2009, p.147). The future is filled with the attainments and mistakes of the past and present, which enable or disable possibilities; and well reading the past and present events would be helpful.

Creating present and futuristic scenarios for the use context whereas they include mainstream and non-mainstream[1] potential end-users and performance environments, helps provide a focus for the design team and ensure that they may consider needs beyond their own immediate experience based on *self-observation* or/and following the *average case model*.

The goal of using *realistic accurate scenarios* is to make the design community able to contemplate large-scale relational complexity resulting from the dynamic variety of contexts characteristics related to use. Thus, it's expected that *inclusiveness* could be attendant – equal usability could be ensured. Accurate scenarios could potentially help attract design

[1] – non-mainstream end-users such as the impaired, elderly and novices; and non-mainstream performance environments include all non-standardized performance environments hindering ease of use.

practitioners' attention and *empathy* towards the excluded end-users from easy use of the mainstream designed things. It attracts attention to the total contextual factors related to the use relation, and helps learn about the different conditions and communicate the corresponding real-world issues to others. In turn, this can be a major force towards raising awareness and changing attitudes of the design community regarding equity and inclusivity (regarding equal usability). This may change the designers' learning curve and lead to creative thinking.

Equally, poor or imprecise scenarios could lead to assuming that the real contexts have been considered and the end-users' needs have been understood, which might result in inadequate assessment decisions, thus, unequally usable outcomes again. The fewer the excluded end -users, the more successful the proposed scenarios are.

> *While the story that is to be enunciated is a fiction, it has to be written from well-researched sources. Moreover, writing such a scenario requires a critical imagination in which creativity cohabits with a skeptical view of sensational predictions. ………. The narrative written is not a presentational document, but a reference work.* (ibid.: p.148)

Obviously, the field of action of the scenario can traverse a broad range of contextual (personal, environmental and chronological) parameters; however, it has to stay within the realm of *credible fiction*. More than one voice can assist in establishing a critical and credible narrative. Thus, different kinds of expertise, cultural backgrounds or politics may significantly and productively change perspectives. (ibid.)

The scenario needs to be elaborated in more detail to attach itself to specific circumstances in which the narrative can be tested for its credibility (ibid.: p.149). The characteristics included in the scenario must be realistic and truly representative in the potential contexts. This involves a thorough inclusion of their characteristics related to the use relation, and ideally a direct mapping to the number of contexts with such characteristics across the wider expected contexts. So, a deep understanding of the use relation and its related different contextual factors is a critical element in creating realistic scenarios. Also, identifying the *context demographics of the target populations* is important because it helps the design community create the required realistic scenarios.

For building scenarios for the current reality for equal usability, just try to imagine for example, impaired individuals, elderly, clinally different individuals, others with abnormal body measures and novice users as a part of the targeted users; in addition, try to imagine the physical world, support, policies and external attitudes in negative features which hinder ease of use of the proposed designed thing. Another simple example is to create a scenario in which a proposed designed thing would be used by all family members, neighbours, friends, colleagues, relatives spreading across other cities, and acquaintances of different nationalities, with considering their performance environments. This may cover a good number of the dynamic and diverse characteristics of use contexts. Such scenarios widen the range of usability requirements in the design brief.

For building futuristic scenarios considering the effect of time and for equal usability, just try to imagine, for example, potential negative changes in body abilities and skills levels of individuals and populations, other personal abilities level, and features of the physical world (such as climate change induced by global warming), support, policies and external attitudes. According to these scenarios, such predictive potential changes in the context characteristics related to use widen the range of usability requirements in the design brief.

2.11.8. Eliminating the fears – Motivations:

With calls for change, fears and defensive assumptions come; it's a repeated phenomenon. The previously proposed keys may successfully work in changing the perceptions (raising the awareness) of the aimed actors. But without removing their fears towards the aimed change, actors may not step to change their attitudes. Any desire to change the attitudes of the design and business community regarding the *design for equal usability* approach requires removing the fears. Some issues may be considered as attitudinal barriers to changeability and enthusiasm towards this approach.

Regarding the design community, fears or defensive assumptions often revolve around[1]:

- *Design for equal usability* would add more requirements and include diverse guidelines arising from having to consider all contextual factors related to use relation, in turn, may constrict and abort creativity; e.g. the idea that black on yellow offers the best contrast available, or certain fonts are set as ideal for readers with poor vision, would limit the chances of creativity.
- Outcomes would be often poor; stereotypical images about old and impaired people who are traditionally seen as beyond the pale in terms of style. Perhaps the medical models contribute to this view as do visions of the poorly designed special equipment upon which impaired people depend, through no fault of their own, but which have given rise to the idea that aesthetics are low on their agenda.
- The absence or lack of suitable formats of the required huge information aimed at designers would cause confusion, which in turn may affect the whole design process.
- Within the highly pressing constraints and deadlines of commercial design projects, there's a widely-held perception that implementing many new requirements is difficult to achieve, especially where the project is complex, involves other actors who may not adopt the same agenda or where the client is resistant.

To argue these fears or defensive assumptions, the debate about the reduction of creativity could stress on the nature of design as a creative process which flourishes with increasing requirements. The reality of creation is to overcome the challenge. Actually, creativity motiv-

[1] These fears have been mentioned by designers who were asked about their attitudes towards inclusive design (Cassim, J.: 2007, Empowering designers and users, p. 104).

ates design practitioners to be challengeable. Also, poor stylish outcomes shouldn't be seen as a source of fear, but as a result of design failure to adopt the equity, which in turn maximizes the challenge. The upcoming successful case studies can demonstrate how *equally usable design* can foster innovation and improve design, and show how it can combine inclusivity with style.

Regarding difficulties of achievement under the highly pressing constraints and deadlines of commercial design projects, changing the attitudes of the business community would be effective in eliminating this fear. As for the lack of appropriate formats of the required huge information, according to the principle of supply and demand, the demand for these formats would be the motivation of creating them.

Regarding the business community, fears or defensive assumptions may revolve around:

- The expensive cost of adopting *design for equal usability* approach in the short term for the benefits it offers whether through a single solution or diverse solutions.
- The absence of motivations: the existing companies not adopting the *equal usability* approach may ask why we need to rethink our business model, reshape our consumer offer, retrain our staff, or build a new knowledge base to adopt this approach; this will require time, effort and money being a considerable obstacle and challenge.

Clearly, there's a need for businesses to see a direct connection between *equally usable design* and *profitability*. To argue these fears, we could stress on the following:

- The new reality and critical changes mentioned in section 2.9.1 would encourage adopting *design for equal usability* approach; it offers a great and ready-to-catch opportunity to add countless numbers of excluded people to the targeted users of a designed thing as well as to increase satisfaction for those who previously had difficulty to use it. Those excluded represent a huge untapped market for profitable growth via expanding the consumers' base. Just think about 1 billion older adults aged 60+, millions of impaired people, equality between sexes, multi-racial societies, millions of people with abnormal body measures, people falling within a wide and uneven spectrum of skills, and countless designed things crossing borders. *Design for equal usability* will become even more important as this reality persists, especially when it's acknowledged and adopted by competitors.

- Ignoring the new reality regarding changes in individuals' expectations and aspirations, especially with the increase of international and governmental legislations of discrimination, may put commercial success at risk. The quest for independence and equal rights has grown among people whatever their categories; now, people aspire to active participation within the mainstream of society, and the marginalized groups – such as the elderly and impaired people – are becoming more assertive in their demands. Not paying attention to this reality makes these groups turn toward other entities that provide what meets their expectations and aspirations.
- Considering the *equal usability* in the design process results in designed things that could have an *added value* for those already included/served – now and in the future when their contextual characteristics related to use may change. Design improvements aiming at the inclusion of *those outside the average* – such as elderly and impaired people, novices, and people in non-standardized performance environments hindering ease of use – can offer real benefits to the *served average*; in turn, outcomes of such improvements can achieve market advantages. There's a good reason to believe that innovations in this area will deliver important usability gains in the future (Cassim, J.: 2007, Towards inclusion, p. 230). Several designed things have been directed to serve the elderly and impaired and have been becoming mainstream things offering real benefits to young able-bodied people (Cassim, J.: 2007, Why Inclusive Design? p. 15). See section 2.11.4. Working at the margins.

Successful implementation of *design for equal usability* can result in a designed thing that is equally usable and ultimately profitable. Design decisions based on appropriate insight into the reality are likely to carry less risk (reduce the risk of undesirable and costly problems in the development lifecycle of designed things); and ultimately lead to clear differentiation from the competitors (build competitive advantage), customer satisfaction and loyalty (encourage repeated purchases), and market success (Coleman, R.: 2007, Intro., p. 1-128).

Though the field lacks substantial data and comparative assessments as to the costs of designing for the broadest possible population, it may be argued that the cost of unequally usable design in the medium- to long-term – the cost of *reactive solutions* to solve its downstream problems – is comparatively much higher and is likely to increase even more (Emiliani, P.: 2009, p. 2-9). Regarding those being responsible for exclusion, in practical terms, the *designed thing-level reactive action* practically often implies redevelopment from scratch;

due to the high costs associated with these reactive actions, it's considered the least favourable option for providing alternatives (ibid.: p. 2-6, 2-7). Failure to correctly adopt the *equal usability* can result in designed things that unnecessarily exclude people and leave many more frustrated; in turn, this leads to downstream problems – such as increased customer support costs, rectification work, lawsuits and warranty returns from unsatisfied customers[1] – which can ultimately reduce commercial success (Coleman, R.: 2007, Intro., p. 1-10). 'In reality, the true costs of bad design …… emerge later on in the product lifecycle, and have the potential to cause irreparable damage to the brand image through customer frustration' (ibid.: p. 1-18) – a bad reputation. Such problems and frustrations are things we remember, and they have a big impact on brand perception and loyalty (Cassim, J.: 2007, Why Inclusive Design? p. 15). The cost of change or reactive solutions increases exponentially throughout the design and development lifecycle; such costs can be minimized by ensuring a thorough understanding of the equal usability, addressing it at the start of the design process (early in the conceptual design stage)[2], and correctly translating this into appropriate requirements and specifications (Coleman, R.: 2007, Intro., p. 1-28). Good design helps manage development risk (ibid.: p. 1-26). Actually, '*good design costs, but bad design costs more*'[3].

The following case studies can demonstrate how *equally usable design* can be put into practice effectively in a commercial context, combine inclusivity with style, and produce things that are both equally usable and effective. They provide compelling examples of *design* and *business* success. They help eliminate the fears of the design and business community regarding the *design for equal usability* approach.

---

[1] inclusivedesigntoolkit.com/why/why.html

[2] A report from the Design Council demonstrated that changes after release cost 10,000 times more than changes made during conceptual design. (Mynott, c. et al.: 1994)

[3] inclusivedesigntoolkit.com/promotionpres/promotionpres.html

2.11.8.1. Successful case studies:

The following case studies are chosen to prove that the *equally usable design* approach can foster innovation, improve design and create considerable commercial value – achieve market advantage, especially when managed effectively.

1. OXO Good Grips:

More than 28 years ago, Sam Farber noticed his wife was having trouble comfortably holding her peeler due to arthritis. This got Sam thinking: why do ordinary kitchen tools hurt your hands? Why can't there be wonderfully comfortable, easy-to-use tools? Sam saw an opportunity to create more thoughtful cooking tools that would benefit all users and promised his wife that he would create a better peeler. (oxo.com)

In 1990, the first 15 OXO Good Grips kitchen tools, including the now-iconic peeler, were introduced to the US market. OXO Good Grips was the brainchild of Sam Farber, He recognized a business opportunity as a result of a gap in the market and sought to capitalize on his experience in the kitchen goods market (Coleman, R.: 2007, The Business Case, p.33). Such ergonomically designed, transgenerational tools set a new standard for the industry and raised the bar of consumer expectation for comfort and performance (oxo.com).

OXO Philosophy is dedicated to providing innovative consumer products that make everyday living easier. They study people – lefties and righties, male and female, young and old – interacting with products and identify opportunities for meaningful improvement. (ibid.)

OXO was founded on the philosophy of *UD*, which means the design of products usable by as many people as possible (ibid.). The company strategy is based on the primary goals of making products that are usable and desirable (Coleman, R.: 2007, Intro., p. 1-16). User understanding and research were at the heart of this process (Coleman, R.: 2007, The Business Case, p.34). Good Grips has been a remarkable success: it achieved a turnover of US$3 million in 1991 and over 100 international design awards, including the distinction of being exhibited in New York's Museum of Modern Art (ibid.). Today, OXO offers 1000+ products covering many areas of the home, all created based on this principle. The company has been recognized globally as an example of how a well-executed *UD* philosophy not only creates products that are beneficial to end users but is also a sensible business model; the annual growth in sales was over 35% per year from 1991 to 2002 (Coleman, R.: 2007, Intro., p. 1-16). The following shows 3 of its main products.

OXO Angled Measuring Cup: The measuring jug has a conventional scale on the outside for liquid measures. However, user tests with traditional products revealed that, after pouring liquid into jugs, people would either lift them to the eye level or bend down to the level of the liquid to read the volume off the scale: a difficult and cumbersome process (Coleman, R.: 2007, The Business Case, p.36). These observations inspired the unique feature of the OXO design: an oval scale wrapped around the inside of the jug that allows the quantity to be read off directly as the liquid is poured in (ibid.). The patented angled surface allows you to see measurement markings from above as you're pouring, so you can measure accurately from above liquid ingredients without bending or lifting the cup to eye level (oxo.com). This eliminates the need to fill, check and adjust the amount of liquid you are measuring (ibid.). That scale does the job well, is clearly visible – a great help to ageing eyes (Coleman, R.: 2007, The Business Case, p.36). Also, it has a soft, non-slip handle for a comfortable grip, even when hands are wet or oily (oxo.com). This scale conveys the core values of the OXO brand: distinctive ease of use and fitness for purpose (Coleman, R.: 2007, The Business Case, p.36). See fig. 2.24.

Fig. 2.24: OXO Angled Measuring Cup (oxo.com)

OXO Salad Spinner: It requires a minimal capability to use. The salad spinner went through a development process: testing existing products, setting key user issues and seeking innovative solutions. Existing products depended on a winding action applied by a spinner handle, or a swinging action to shake off excess water. Neither action was satisfactory, or efficient in drying salad. A review of possible mechanisms with users pointed to the pump action of children's spinning tops. An equivalent pump action was developed with a simple press of the soft, non-slip knob that is much easier to operate – requiring a minimum of grip and a very simple hand motion – and delivers excellent results. Indeed, the one problem with the design was that the bowl continued spinning after the pumping stopped. This prompted the addition of a brake button which, although not technically necessary, introduced a greater sense of user control, while conveying the functionality and efficiency of the product. The built-in brake button stops the Salad Spinner for unloading and the non-slip base keeps the bowl steady on the countertop. See fig. 2.25. (Coleman, R.: 2007, The Business Case, p.37 and oxo.com)

Fig. 2.25: OXO Salad Spinner (oxo.com)

OXO Swivel Peeler: It has an innovative design that makes it comfortable to use, and its handle is made from very carefully selected material to enhance and cushion the grip to make the product more comfortable for those suffering from arthritis. The cushioned grip won't slip, even when hands are wet. The peeler has unique fins near the top of the handle which offer a natural resting place for the thumb. This patentable feature became a signature detail for the range. The blades are functionally very effective. See fig. 2.26. (oxo.com and Coleman, R.: 2007, The Business Case, p.34)

Fig. 2.26: OXO Swivel Peeler (oxo.com)

2. STABILO EASY start family[1]:

Learning to write has never been easier. There’s no doubt that learning to write can be a tough and tiring time, but the right tools can make things easier. The EASY start family provides the perfect handwriting pens and pencils for early writers. The EASY Start Family is a colourful and ergonomic range especially designed for learning and improving handwriting skills at a young age. The products were developed with the assistance of motor skills experts – Prof. Dr. Ing Ralph Bruder, Head of the Institute of Ergonomics at the Darmstadt University of Technology, and Dr. Christian Marquardt, fine motor skills expert, Munich-Bogenhausen Hospital. The pens and pencils are available in right or left-handed versions. Every product is designed with special purposes that won’t only provide an intelligent and intuitive fundament for beginners but are also truly fun to use.

[1] stabilo.com/com/stories/easy-start/

STABILO EASYgraph: The STABILO EASYgraph ergonomic pencil helps children learn to write in comfort and with ease. Tested by expert scientists in several fields including ergonomics, the STABILO EASYgraph is a deceptively sophisticated but fun companion for children who wish to learn to write. The triangular design with its non-slip grip moulds ensures a comfortable and relaxed handwriting experience over long periods. It's available in right- or left-handed versions and comes in 5 vibrant and fun colours. See fig. 2.27.

STABILO EASYergo 3.15: It's an ergonomic and refillable mechanical pencil, specially designed for right- and left-handed children aged 5 years and above. Being mechanical may make it sound complex, but it's actually made in just 2 simple parts and is completely safe for children. Its break-resistance and extra-thick 3.15mm lead make it perfect for children as they learn to write, and the ergonomic shape means it's extremely comfortable for a child to hold. It's available in a range of stylish colour combinations with space for a name tag. See fig. 2.28.

STABILO EASYoriginal: Scientists say that learning to write is one of the key aspects of a child's development, but it can also be one of the most challenging. The fun STABILO EASYoriginal pen is the first ergonomic refillable rollerball for left- or right-handers, uniquely designed for children as they learn to write. It has been designed to help children aged 6+ take their first steps towards clear, legible writing. The ergonomic, non-slip grip prevents muscle fatigue and writing pain, enabling an optimal writing experience. The ease with which the ink glides across the paper means learning to write is something all children can enjoy. It's available in a range of trendy colours; there's a design for every child to love. See fig. 2.29.

STABILO EASYbirdy: It's a fountain pen ergonomically designed for either left- or right-handed children aged 7+. It has an ergonomic grip zone made from non-slip material for either hand. The unique design allows the nib of the fountain pen to be fitted in 3 different angles (by the retailer only). This feature allows the child to find an ergonomic writing posture that is perfectly suited to their hand. It comes in 5 popular colour combinations for right-handers and 3 for left-handers. See fig. 2.30.

Fig. 2.27: STABILO EASYgraph for left-handers on the left side and for right-handers on the right side (stabilo.com/com/stories/easy-start/)

Fig. 2.28: STABILO EASYergo for left-handers on the left side and for right-handers on the right side (stabilo.com/com/stories/easy-start/)

Fig. 2.29: STABILO EASYoriginal for left-handers on the left side and for right-handers on the right side (stabilo.com/com/stories/easy-start/)

Fig. 2.30: STABILO EASYgraph for left-handers on the left side and for right-handers on the right side. (stabilo.com/com/stories/easy-start/)

3. STABILO EASYsharpener:

The STABILO EASYsharpener is ergonomically designed for preschool children aged 5+ and can sharpen 3 different lead diameters. It’s available for left- and right-handers. The version for left-handers comes in 3 colours and the version for right-handers comes in additionally 2 colours. The innovative moulded grip makes it comfortable for the smallest hands and optimal hold. It has a closable lid and a safety screw to prevent injuries.[1] See fig. 2.31.

Fig. 2.31: STABILO EASYsharpener for left-handers on the left side and for right-handers on the right side. (stabilo.com/com/stories/easy-start/)

[1] stabilo.com/com/stories/easy-start/

4. Hultafors hammers[1]:

Hultafors is a leading international brand within state-of-the-art hand tools designed for construction and industry. It all started more than 130 years ago with the innovation of the folding rule. One of its main products is hammers which are good ergonomically designed products. In the last decade, Hultafors has offered a range of hammers in small, medium and large handle sizes to fit an extended range of users' hands: both men and women can use the hammers with ease. For example, the handle of Claw Hammer TC 16 comes in 2 different sizes, L and XL; the same Claw Hammer TC 20 – fig. 2.32.

Fig. 2.32: The handles of Claw Hammer TC 16 and 20 come in 2 different sizes (youtu.be/SH9eIFMSoZs)

5. Lindstrom Rx cutters:

Lindstrom is one of the oldest continuous manufacturers of hand tools in existence and yet one of the most forward-looking brands in the world. It developed the scientific approach to handtool design and created many unique ergonomic pliers and cutters. The more recent series of Lindstrom Rx electronic cutters and pliers being intensively used by operators in the manufacture of printed circuit boards is a perfect example of equally usable design; such products have an adjustable handle width and spring force, designed to include women users – fig. 2.33, 2.34 and 2.35. This series started with an *inclusive design* brief. (Dong, H.: 2007, p. 59 and lindstromtools.us)

[1] hultafors.co.uk/about-us/

The design factor mostly appreciated in the Rx cutter was the ease with which the operator could pick up the tool from the table. Operators use the tools not only for cutting, but also for reaching and grasping the shanks to lift them from the desk and place them in the proper position in the palm. This sequence may be a risk factor for epicondylitis (inflammation in the elbow due to overuse), as operators may have to extend their wrist and open their hands very wide in order to get a firm grip over the tool, which is often placed on a workbench by the operator. (Dong, H.: 2007, p. 67)

Operators with small hands had obvious problems in placing some of the other tools in their hands. To avoid opening their hands very wide, methods were seen by which they picked up the tool in one shank and moved the tool over in their hand in order to get it properly placed. The Rx cutters were equipped with a return spring designed so that the shank width could be set by the operator to reduce it. Moreover, the return spring has a specific force displacement characteristic, which gives the shanks a firmer resistance when fully open to ease the task of picking up the tool. The material and texture on the surface of the shanks in palm contact has been selected to provide optimum friction and least discomfort as a result of palmar friction studies (Bobjer, O.: 2004). (ibid.)

Although the cost of these tools is higher than traditional tools, it can be justified as follows (ibid.: p. 68)*:*

- *The traditional range of cutters causes considerable pain and discomfort, while the Rx range is comfortable to use.*
- *Nortel Networks health care providers reported fewer calls concerning upper limb complaints/ discomfort since the Rx tools were introduced as the company's regular cutter.*
- *The samples of Rx tools are in good condition and fully functional after 20 months.*
- *The spring in the Rx is a separate component, which can be replaced by the operator.*

Over a 28-month period of testing, Peter McBride, the ergonomics specialist at Nortel Networks, has drawn the following conclusions: although the Rx cutters are more expensive than most of the existing cutters, they last much longer: of the 26 pairs of Rx cutters issued, 22 pairs were still in good condition after 28 months of use, compared with existing cutters which have to be replaced at least 4 times/year. The total cost reduction equates to US$100 per operator per year. (ibid.)

Fig. 2.33: A pair of Lindstrom RX cutter (cdn.astrojewelry.com/api/i/28368948/520/32_media_catalog_product_r_x_rx8141.jpg)

Fig. 2.34: RX cutter in operation (aajewelry.com/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/n/e/newfinal_1.jpg)

Fig. 2.35: Adjusting the handle width and spring force of a Lindstrom RX cutter to fit a woman's hand size (hisco.com/UserFiles/Images/Products/lindstrom-30425_rx8000_DV_WebXL.jpg)

6. Toyota Sienna Auto Access Seat:

Toyota is committed to finding a variety of mobility solutions for its owners. Sienna offers the Auto Access Seat as the perfect solution for anyone who needs a little extra help getting in and out of the vehicle with ease. Designed as a bucket seat in the second row of the Toyota Sienna, the Auto Access Seat takes it to the next level by rotating 90 degrees, extending from the vehicle, and lowering to an appropriate height for the passenger to board. Because the seat is specifically engineered for the Sienna, safety features prevent the power door from operating if the seat is deployed and keeps the shifter in Park. The Auto Access Seat has a lift capacity of 330 lbs, wireless remote control and manual override capability. The seat is operated by buttons on the seat base but a wireless remote feature adds convenience. The Auto Access Seat is engineered by Toyota and factory installed to ensure the best possible operation. Specifically designed for Sienna, it's the first rotating power-ascending/descending seat to be engineered and installed by a major auto manufacturer. Since it's a factory -installed feature, the seat matches the interior of Sienna and is covered under the same comprehensive 3-year factory warranty as the rest of the vehicle.[1] See fig. 2.36.

Other previous solutions have been offered by Toyota for helping elderly persons or those with disabilities get into and out of the Toyota with ease. For example, Porte (2004) offers a novel solution for enabling access to the car seats, through the use of an electric sliding front door on the passenger side, not a conventional hinged door – fig. 2.37.

[1] toyota.com/sienna/ebrochure/ & toyotavacaville.com/blog/what-is-toyota-sienna-auto-access-seat/ and toyotamobility.com/mobility_solutions.html

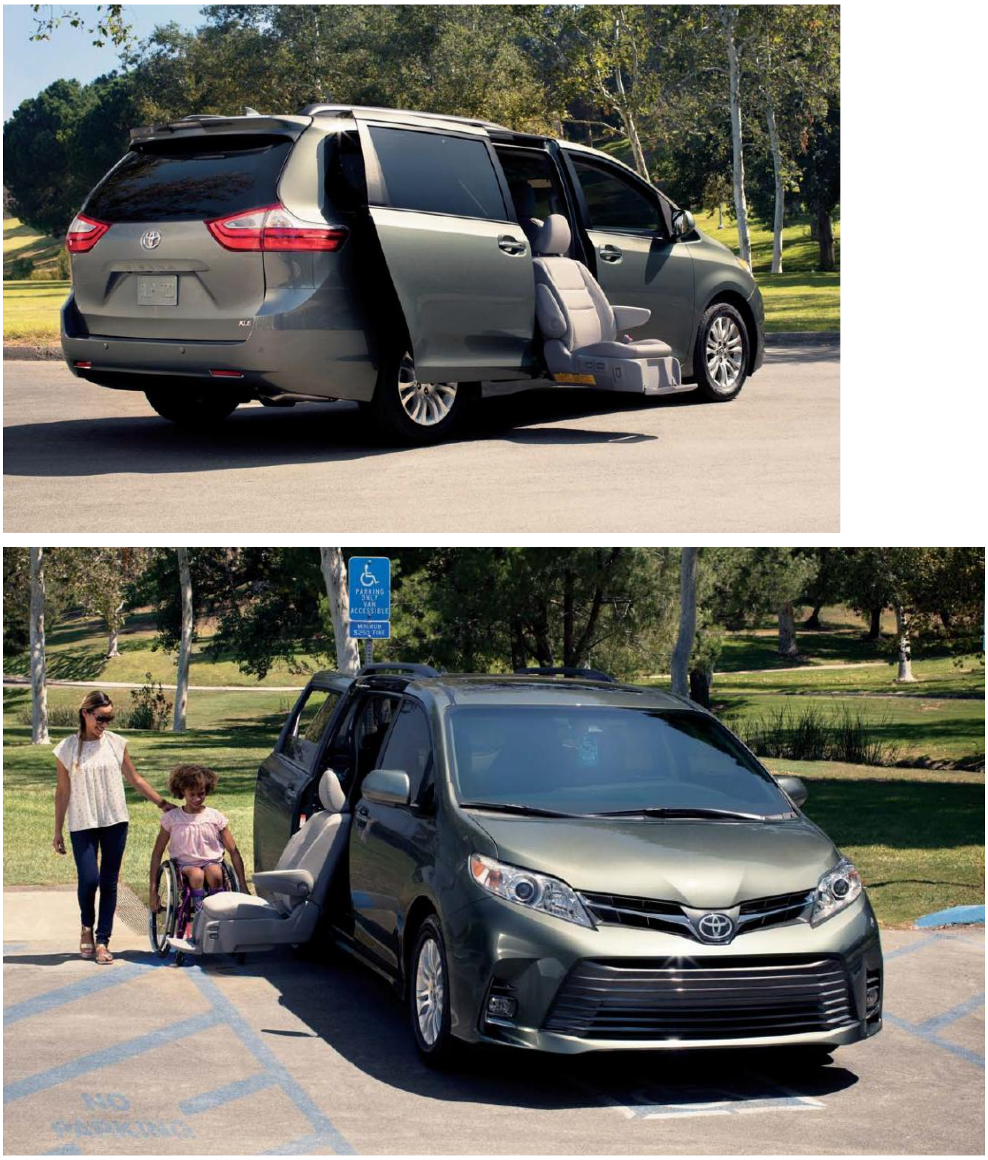


Fig. 2.36: Toyota Sienna with an Auto Access Seat (toyota.com/sienna/ebrochure)

Fig. 2.37: Toyota Porte with an electric sliding front door on the passenger side (upload.wikimedia.org/wikipedia/commons/thumb/7/7f/Toyota_Porte_02.jpg/1200px-Toyota_Porte_02.jpg)

7. Adjustable office chairs and desks:

Today, office chairs often have adjustable seats, armrests, backs, back supports, and heights to prevent repetitive stress injury and back pain associated with sitting for long periods. Ergonomic chairs fit an individual's needs and provide support where the individual needs it. With such adjustable features in an office chair, many people with different body measures can use it with ease; i.e. it fits an extended range of users. For example, since the 80s of the last century, Herman Miller, Inc. the American company that produces office furniture has adopted a *more democratic solution away from the stereotypes*, via designing adjustable office chairs that fit all people and provide comfort[1], e.g. Aeron chair – fig 2.38.

Fig. 2.38: Adjustable Aeron office chair based on many controllers helping adjust the chair parts to be more equally usable – by Herman Miller (hermanmiller.com/products/seating/office-chairs/aeron-chairs/product-images/)

The same could be mentioned regarding height-adjustable desks and tables. There are many types of mechanisms used for this option – fig. 2.39. Recently, Herman Miller, Inc. offered height-adjustable desks relying on sensors; these desks recognize and respond to personal preferences with one tap of the desk control.

[1] hermanmiller.com/products/seating/office-chairs/aeron-chairs/ and youtu.be/Gb5iHzCT7Tk

IKEA Height-adjustable desk (i2.wp.com/anguloconsulting.com/wp-content/uploads/2017/05/ikea-height-adjustable-desk-uk.jpg)

Winding handle height-adjustable desk (heightadjustabledesks.com)

Electric height-adjustable desk (heightadjustabledesks.com)

Fig. 2.39: Height-adjustable desks via different types of mechanisms to be more equally usable

8. Whirlwind Roughrider: a low-cost and highly functional wheelchair

Millions of people worldwide require a wheelchair to perform daily activities but lack access to one. Those are often among the most disadvantaged and impoverished people in societies. The challenges faced by those in need of a wheelchair and living in low-income societies are even great (Chick, A.: 2011, p. 156). In 2010, Whirlwind offered RoughRider wheelchair allowing users 'to travel across varying rural and urban and terrain-broken pavement, high curbs, rocky trails, etc. The chair is made from low-cost, readily available parts such as mild steel, bicycle bearings, and tires for easy maintenance regardless of location'[1]. It's a low -cost and highly functional wheelchair that lasts and lasts even in rough conditions of different environments. Whirlwind has built a network of certified factories and assembly shops around the world, and currently, wheelchairs are being produced in independently owned sites in Mexico, Vietnam, Canada, Georgia, China, and South Africa[2].

The Roughrider 'is designed to handle rugged terrain with ease. It has been proven in over 25 countries by thousands of riders who live in the worst of conditions and need the best of chairs. Riders use it as a super-durable daily-use chair or in the US and Canada as a backup when life calls for off-pavement adventures.'[3] See fig. 2.40 and 2.41.

> *Whirlwind Wheelchair International is a non-profit social enterprise dedicated to improving the lives of people with disabilities in the developing world while also promoting sustainable local economic development in the process. It works to make it possible for every person in the world who needs a high quality wheelchair to obtain one, leading to maximum personal independence and integration into society. By giving wheelchair riders a central role in all aspects of designs and projects, Whirlwind ensures that chairs are individually appropriate for each user and his or her respective environment. For thirty years in over 60 countries they have focused on producing durable, low-cost, and highly functional wheelchairs. ……….. RoughRider® is used by 60,000 riders traveling over every terrain that only the best of wheelchairs can cross, from muddy village paths to rough pot-holed urban streets.*[4]
>
> *Wheelchairs, like cars, are about mobility and safety. Driving a city car off-road will most likely leave a person stuck and frustrated. For wheelchair riders in rough developing world conditions,*

[1] designother90.org/solution/whirlwind-roughrider/

[2] whirlwindwheelchair.org/

[3] whirlwindwheelchair.org/about-us/

[4] ibid.

the difference is that they cannot afford repairs and they cannot walk away from these situations. That's why Whirlwind chairs are super-durable and capable on almost any terrain and use parts and materials that are readily available throughout the developing world.[1]

The functional usefulness of a wheelchair affects the opportunities a rider can access as well as public perception of the rider and of disability. …….. A functional wheelchair designed for the challenges of its environment is a tool that enhances the rider's ability to participate in family, social and economic activities.[2]

Fig. 2.40: Arnulfo Criollo on his RoughRider going down one of the many ramp-less curbs in Cali – Colombia (designother90.org/solution/whirlwind-roughrider/)

Fig. 2.41: A stylish version of Whirlwind RoughRider wheelchair for people in developed countries (whirlwindwheelchair.org/)

[1] whirlwindwheelchair.org/about-us/

[2] ibid.

Conclusion:

- The aforementioned case studies in section 2.11.8.1 can explain how *equally usable design* can be effectively put into practice. They serve as proof that *designing for equal usability* is a *realistic goal* and can be an achievable, worthwhile, and rewarding enterprise; and it can result in better designed things with widely greater user satisfaction and commercial success whilst reducing product development risk. They provide compelling examples of *design* and *business* success. They help eliminate the fears of the design and business communities regarding the *design for equal usability* approach and light up the way for them to do their neglected roles.
- These case studies demonstrate how the *design for equal usability* approach can foster innovation and improve design, and show how it can combine inclusivity with style. They prove that designing for *those outside the average* doesn't limit the chances of creativity or doesn't necessarily lead to outcomes that are poor style.
- Excluding Whirlwind Roughrider, all case studies were launched via a *profitable chain*. They are already in the market and prove that the *equally usable design* approach can create considerable commercial value – achieve market advantage. They prove that there's a direct connection between *equally usable design* and *profitability*, and profits could be achieved not only by the common keys (manufacturing processes, developments in technology, product innovation and provision of ever-widening services (Coleman, R.: 2007, The Business Case, p.41) but also by adopting inclusiveness increasingly important to attract and retain satisfied customers. Regarding the example of Whirlwind Roughrider, it was launched through a *non-profitable chain* by Whirlwind Wheelchair International being a non-profit social enterprise.
- These case studies demonstrate that for ensuring *inclusiveness* and *practicality* via *design for equal usability* approach, the *one-solution-fits-all* path isn't necessarily the only path, but it's the main path and there are other paths supporting it when it's insufficient – i.e. through a single solution when possible or diverse solutions when not. These case studies follow one path of the following paths:
    - Reduce the level of ability (the body ability levels and skill level) required to use the designed thing as much as possible to achieve usability for an extended range of contexts; this expresses the *one-solution-fits-all* path; e.g. OXO Good Grips and Whirlwind Roughrider wheelchair.

- Make the designed thing adaptable or adjustable (add adaptive or flexible features to the same designed thing); e.g. Lindstrom Rx cutters, Toyota Sienna Auto Access Seat, and adjustable office chairs and desks.
- Offer the designed thing in other modified versions; e.g. STABILO Easy start family, STABILO EASYsharpener and Hultafors hammers.

All case studies are *context-fit* solutions offered to match the empowerment-related characteristics of the contexts of the underserved.

- While the case studies of OXO Good Grips and Whirlwind Roughrider wheelchair don't imply a separate, specialized or segregated solution, the case studies of STABILO Easy start family, STABILO EASYsharpener, Hultafors hammers, Lindstrom Rx cutters, adjustable office chairs and desks, and Toyota Sienna Auto Access Seat show different levels of *customization*.
- The majority of such case studies point out that *localization* should be attendant *in some way* for equal usability. Some of them are created to fit specific contexts and similar (to *address* local conditions, reality or capabilities regarding access – localizing the solution), they are cases *not* following the *one-solution-fits-all* path – see STABILO Easy start family, STABILO EASYsharpener, Hultafors hammers, Lindstrom Rx cutters, adjustable office chairs and desks, and Toyota Sienna Auto Access. Also, Whirlwind Roughrider wheelchair shows another form of *localization* via depending on local factories and assembly shops.
- RoughRider wheelchair demonstrates that things designed for the underserved could have an *added value* for those already included/served – now and in the future when their contextual characteristics related to use may change. The wheelchair being affordable, locally manufactured and highly functional in *rugged terrain* has been found for the poor impaired people in *rough conditions of different performance environments in undeveloped countries*, and it's currently being marketed in developed countries (U.S., Canada, Europe, Australia and New Zealand) but in more stylish versions as a backup when life calls for off-pavement adventures. Actually, designing for the *underserved people* can result in things that work better for everyone or bring about advantages for all citizens.
- All case studies demonstrate the real value of design and how it could improve the lives of the *underserved* around the world, and that it's possible to regain more of its lost social responsibility regarding *equity in meeting human needs* (*the 2nd area of SRD model*).

2.11.9. Summary:

Briefly, section 2.11 has provided a journey among the fundamental keys proposed for raising awareness of all actors needed to promote the *equally usable design message* within the design, business and decision-making communities. In this journey, the study has discussed all of the following keys: building up the relevant literature, actively involving diverse potential end-users in the design process, simulating the non-mainstream potential contextual characteristics, working at the margins (outside the range of average case), going deeply into other disciplines related to the use relation, varying the design team members, creating realistic scenarios considering diverse potential use contexts, and eliminating the fears. Also, the rationale for these keys, and the positive impact that such keys can have on the aimed actors and the final design outputs have been discussed. In addition, the journey has reviewed some of the considerable and valuable efforts undertaken regarding some of these keys, such as those efforts regarding the active involvement of diverse potential end-users and the simulation of the non-mainstream potential contextual characteristics. Furthermore, the journey has reviewed some effective case studies to give certainty in the *design for equal usability* approach and eliminate the fears and doubts about it.

2.12. The origin & advancement of 'design for equal usability' – A widening circle over time:

Design for equal usability isn't born of the moment; we can give credit for its emergence to the successive design approaches starting from the 1950s till now. It's a result of a long history of individuals' and organizations efforts that called for and/or supported consideration of one or more personal factors related to the use relation – such as impairment or ageing. It could be said that it has its beginnings in demographic, legislative, social and economic changes related to people with impairments throughout the middle of the 20th century.

2.12.1. Beginnings – New thinking:

At the end of the 1950s, a process of change in public policies and design practices started in the US (Persson, H.: 2014, p. 507 and Story, M.: 1998, p. 7); approaches such as *barrier-free design*[1] and *design for disability*[2] appeared and took place in the design community. Due to many people returning to the US with injuries after the Vietnam War, the US President's Committee on Employment of the Handicapped, the Veterans Administration and others worked on national standards for *barrier-free buildings*, targeted at making buildings accessible[3] by handicapped soldiers and others with similar conditions (Persson, H.: 2014, p. 507). Physical barriers in the environment were recognized as a significant hindrance to people with mobility impairments (Story, M.: 1998, p. 7). The goal was to offer education and employment opportunities, as an alternative to institutionalized health care (Persson, H.: 2014, p. 507).

---

[1] It was introduced to describe the act of creating barrier-free buildings.

[2] At that time, disability was to be expressed through its limited definition: a lack of ability to use a designed thing or complete a task as a result of *defects in the body functions*/abilities, or it can be used interchangeable with the impairment – people with these defects were previously known *people with disabilities*. Now, *disability related to use* could be defined as a lack of ability to use a designed thing or complete a task as a result of negative effects of contextual factors (personal and environmental factors) related to the use relation. For example, people aren't able to see because they are blind, or have fixation problems due to spastic cerebral palsy, or are in a place with insufficient illumination, or are driving and therefore can't use their eyes for interacting with an information system (Emiliani, P.: 2009, p. 2-8); it isn't only due to impairments, but also for example, due to environmental reasons.

[3] At that time, accessibility meant enabling the use of a designed thing for people with *defects in the body functions*/abilities or special needs, or enabling use of a designed thing through the use of assistive technology. In this research, accessibility is the ability, right or permission to get to a designed thing. The designed thing-person access relation is a prior phase to the use relation; there may not be use interaction if there's no possibility of interaction in the first place – accessibility is a fundamental prerequisite of usability (Stephanidis, C.: 2009, Universal access and design, p. 1-3).

'In 1961, the American National Standard Institute published its first version of ANSI A117.1- *Making Buildings Accessible to and Usable by the Physically Handicapped*. One of the effects of this was the tremendous development of assistive technologies with the purpose of increasing disabled individuals' possibility to participate in everyday life. Examples are most frequent in the area of building and home equipment, such as the one-hand blender, remote controls, and wider doors in trains'. (ibid.)

In 1963, the first comprehensive set of building guidelines on the subject of designing for the disabled/impaired was published by the British architect Selwyn Goldsmith (Myerson, J.: 2007, p. 23, 24); he pioneered the concept of *free access* for people with disabilities (Goldsmith, S.: 1963).

In 1971, Victor Papanek demonstrated the *moral dangers of America's mono-dimensional design* approach in his published book *Design for the Real World: Human Ecology and Social Change*, which challenged the dominant *market-led* approach to industrial design and called for more *social responsibility* from designers (Papanek, V.: 1971). Papanek's ideas reputation has grown among European designers; e.g. in Sweden, Maria Benktzon and Sven-Eric Juhlins of Ergonomi Design Gruppen were inspired by his ideas of developing new tools for older and impaired people. Such tools combined functionality, performance and aesthetic appeal in a way that positioned them within the mainstream of consumer products *rather than as disability aids or equipment* (Myerson, J.: 2007, p. 26).

At the beginning of the 1970s, the work advocating for people with disabilities of the American architect, designer and educational pioneer Ronald L. Mace effectively defined the concept of *UD*, which was further advanced through the Adaptive Environments Centre, Boston, founded in 1978 (ibid.: p. 24).

Ronald L. Mace was instrumental in North Carolina's March 13, 1973, adoption of Chapter 11X, which was the first *accessibility-focused building code* to be adopted in the US. This code was one of the foundations of the later movement to pass federal legislation prohibiting disability discrimination, including the Fair Housing Amendments Act of 1988 and the Americans with Disabilities Act of 1990. He also worked on the Rehabilitation Act of 1973. Mace was the president and registered agent of Barrier Free Environments, Inc., which was founded in 1974. It was a consulting firm focused on *accessibility* and *UD*. (NCSU Libraries and Wikipedia: Roland Mace)

Mace realized that *accessibility* and equal opportunities depended not just on better ramps or more accessible toilets but on the details of all our interactions with the designed world. He shifted the debate beyond accessibility *perceived in terms of adapting buildings or products to disabled users* and towards ones that are *usable by people of all ages and abilities*, and therefore more universal or inclusive. (Myerson, J.: 2007, p. 24)

In 1976, the landmark international conference *Design for Need* at the RCA in London explored many social aspects of design, including the idea of *designing out disability*. In 1991, the DesignAge action research programme was established at the RCA under the direction of Roger Coleman to explore the design effects of ageing populations. This was supported by the Helen Hamlyn Foundation, a charity set up in 1985 to improve the homes and lives of older people through design. DesignAge put one of the central themes on the map: *the right to freedom of choice, independence and dignity of older people*. After all, ageing is a universal experience − we will all get older. What Coleman and his team managed to do was to make the issue of ageing a hot topic for young designers – by reframing it as an area of self -interest, as *design for our future selves*. DesignAge also established a Europe-wide network called Design for Ageing Network (DAN) to pursue the agenda. In 1999, DesignAge was subsumed into the Helen Hamlyn Centre, a new centre for *inclusive design* at the RCA, with a programme of industry collaborations for young designers. (ibid.: p. 26)

At the beginning of the 1990s, James Pirkl and his colleagues at the University of Syracuse developed the concept of *transgenerational design* to describe designed things that meet the needs of people across a wide range of ages and abilities; they also evolved a series of guidelines and strategies for applying this concept, and similar methods for approaching journalism, advertising, marketing, retailing, and employment policy[1] (ibid.: p. 29). *Transgenerational design* is framed as a market-aware response to population ageing and the need for designed things that can be used by both young and old people living and, importantly, working in the same environment (ibid.: p. 29).

In 1989, in conjunction with North Carolina State University's School of Design in Raleigh, Ronald L. Mace founded the Center for Accessible Housing under a grant from the National Institute on Disability and Rehabilitation Research (NIDRR) with a mission to improve the

[1] – see Pirkl, James (1988, 1991, 1993).

quality and availability of housing for people with disabilities, including disabilities that result from aging. It later became the CUD. It's a national research, information and technical assistance centre that evaluates, develops and promotes *UD* in housing, public and commercial facilities and related products.[1]

2.12.2. Broader approaches:

At the end of the 20th century, huge momentum happened in the field of design; the previous efforts began to give way to more *egalitarian* concepts. Some old approaches have been developed and new ones have been offered to consider more than one contextual factor. *UD*, *DfA*, *inclusive design* and others[2] are effective approaches that largely focus on increasing the usability of the designed things for the widest possible range of people (Persson, H.: 2014, p. 505). These approaches come from diverse origins but over time have been converging to the common goal of *inclusiveness* regarding *usability*. They have been developed over the last 2 decades and can be seen as adopting the vision not limited to discussions on *defects in the body functions/abilities*, but also concerning *diversity*. They put a high value on diversity. But, to what extent have they deeply considered it?

2.12.2.1. Universal design (UD) – in the US:

UD 'has its roots in the *barrier-free design* and *accessible design* approaches' (ibid.: p. 508). The term UD was originally coined by Ronald Mace, a director of the CUD at North Carolina State University (Vanderheiden, G.: 2009, p. 3- 13). He defined it as follows: UD '*means simply designing all products, buildings and exterior spaces to be usable by all people to the greatest extent possible*' (Mace, R.: 1991). UD approach 'resulted in successful designs for landscapes, which were subsequently documented as guidelines for accessible built environments. It took several years before the approach was able to gather the political support needed for practical application, but the main principles had been developed. Moreover, it turned out that the approach was invaluable not only for disabled people, but also for the population at large' (Emiliani, P.: 2009, p. 2-1).

[1] nchpad.org/Directories/Organizations/2558/Center~for~Universal~Design~-~North~Carolina~State~University

[2] – such as *El Disseny per a Tothom*, *Conception Universelle* and *Design d'utenza ampliata*.

In 1997, the CUD defined UD as '*the design of products and environments to be usable by all people, to the greatest extent possible, without adaptation or specialized design*'; and it established 7 principles for the UD of products and environments against which designs could be judged; in addition, it established a set of guidelines for every principle (CUD: 1997). The 7 principles of UD are:

- ***Equitable use:*** *the design is useful and marketable to people with diverse abilities.*
- ***Flexibility in use:*** *the design accommodates a wide range of individual preferences and abilities.*
- ***Simple and intuitive to use:*** *use of the design is easy to understand, regardless of the user's experience, knowledge, language skill or current concentration level.*
- ***Perceptible information:*** *the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.*
- ***Tolerance for error:*** *the design minimises hazards and the adverse consequences of accidental or unintended actions.*
- ***Low physical effort:*** *the design can be used efficiently and effectively with a minimum of fatigue.*
- ***Size and space for approach and use:*** *appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture or mobility.*

In 1998, in its pioneer book: *The Universal Design File: Designing for People of All Ages and Abilities*, the CUD developed the definition of UD without change in the 1997 principles and guidelines to be: '*the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities*' (Story, M.: 1998, p. 2).

The UD definition has served well as a reference point, but it sets no practical limits (overlooking the practicality); what is possible isn't necessarily commercially viable (Vanderheiden, G.: 2009, p. 3- 13). As UD 'moved from a goal to appearing in social legislation, designers began to fear the implications of such an ideal goal (designing things that everyone can use) if the term was used in a requirements context. For example, building a $2,000 Braille display into every electronic device with a visual display isn't generally practical. As a result, some designers began to fight the movement rather than embrace or explore the basic concept' (ibid.).

On the *conceptual* level, despite it's based on the term *universal*, UD concentrates only on equal usability in its definition at the expense of equal accessibility and harmonizability. On the *details* level, UD principles and their attached guidelines confirm and go with the same orientation. In its aforementioned pioneer book, CUD concern was on the spectrum of human body abilities (Story, M.: 1998, pp. 16: 30) and it offered case studies to illustrate each of UD principles according to this spectrum.

'Design for equal usability' compared to UD: Although UD and *design for equal usability* come from quite similar directions, their purposes aren't the same. While the *purpose* of UD is mainly to reduce the physical and attitudinal barriers for integrating people with disabilities into the mainstream (ibid.: p. 11), the purpose of *design for equal usability* is to integrate all people whatever their context (considering the diversity of contextual characteristics related to the use relation). UD reflected the aspirations of campaigning disability groups in the US (Cassim, J.: 2007, Why Inclusive Design? p. 12, 13). The UD principles and their attached guidelines ignore the personal factors indirectly related to the use relation and limit the environmental factors to the physical ones. Additionally, most guidelines comprehensively consider *impairment* and *aging* at the expense of the other personal factors directly related to the use relation. Counter to the intentions of the term originators, UD has become associated with disabilities resulting from defects in the body functions/abilities, much UD guidance categorizes design advice according to constrained categories of such disabilities[1]. On the *applied* level, the UD aim has become as if it was to ensure that no one should be excluded because of their disabilities or functional difficulties.

In contrast, *design for equal usability* stresses that the individual's context is multi-faceted and the constraints or design needs it has, may arise from a number of his/her personal and environmental characteristics related to the use relation, and they all need to be taken into account. So, as opposed to *design for equal usability*, UD isn't a context-sensitive approach considering equity with respect to usability.

On the *realm* level, while UD has its origins and activities in architectural and industrial design and targets built environments and products, *design for equal usability* targets the whole realm of designed things (products, services, systems, environments and technologies), especially, with the shift in focus from products to services.

[1] idrc.ocadu.ca/index.php/resources/idrc-online/library-of-papers/443-whatisinclusivedesign

On the *methodology* level, and with the common goal of inclusion regarding usability, while UD is about creating a single solution that works for everyone, *design for equal usability* gives the freedom to create *when it's inevitable* a design space (diverse solutions) that can adapt, morph, or stretch to address each design need presented by similar contexts. The difference is clear; as opposed to *design for equal usability*, UD sets *no practical limits* by depending on the *one-size-fits-all* solution, but what is possible isn't necessarily commercially viable.

Finally, regarding usability, it can be concluded that *design for equal usability* is broader and more holistic, inclusive and practical than UD in its above-mentioned features. But in the narrow design orthodoxy of the time, UD principles 'were genuinely mould-breaking and a challenge to the status quo; they were also eminently *practical* and could be implemented both as individual design criteria and as an aid to design evaluation' (Myerson, J.: 2007, p. 24).

2.12.2.2. Design for all (DfA) – in Europe:

DfA has its roots in the *barrier-free design* and the broader *notion of UD*. It has been highlighted in Europe. It has been mainly introduced on the basis of serving a variety of users, that is, addressing users' diversity; the related line of reasoning is that since users are different, and they have different *accessibility* and *usability* requirements, it's necessary to take all of them into account in a user-centred design process (Emiliani, P.: 2009, p. 2-5).

In 2004, the European Institute for Design and Disability (EIDD)[1] – renamed in 2006 to Design for All Europe, defined DfA in The Stockholm Declaration as '*design for human diversity, social inclusion and equality*'. Also, it clarified that the DfA aim is to enable all people to have *equal opportunities* to participate in every aspect of society; and to achieve this, everything that is designed and made to be used by people must be accessible, convenient for everyone in society to use and responsive to evolving human diversity. (EIDD Stockholm Declaration: 2004)

[1] EIDD is a European network, founded in Dublin, Ireland, in 1993, to enhance the quality of life through DfA, it changed its name in 2006 to bring it into line with its core business. EIDD is a NGO and a 100% self-financed European organization that covers the entire area of theory and practice of DfA, from the built environment and tangible products to communication, service and system design. It disseminates the application of DfA to business and administration communities previously unaware of its benefits and it's now a federation of 34 Member Organizations in 17 European countries. With a strong interdisciplinary approach, the majority of members are professionals in design-related fields. (EIDD – Design for All Europe)

In 2010, the publication of *Diseños para todos* (Design for All) defined 2 main principles for DfA: 1. facilitate the use of products and services via considering at least 6 premises (respect of the diversity of all users, safety, health, functionality, ease of understanding and use, and attractiveness); 2. ensure that the needs, desires and expectations of users are considered in the process of design and the evaluation of the product or service (Fundación Prodintec: 2010, p. 12, 13). Also, such a publication established a set of 6 strategies to achieve the aim of DfA. Such strategies are (ibid.: p. 16, 17 and designforall.org/design.php):

- ***To Everyone:*** *A single solution suitable for all potential users.*
- ***Adjustable:*** *A single product that meets the different dimensional or functional requirements of people by means of devices or mechanisms.*
- ***Products or services range:*** *A range of products and services among which the person chooses the one best fits.*
- ***Compatible with commonly used accessories:*** *Adaptations or not marginalizing alternative solutions can be provided to guarantee the compatibility with accessories that a person must wear or use.*
- ***Premises/Product & complementary service:*** *Not always it will be possible to meet the needs of users only via a product, a complementary service will then be necessary.*
- ***Use an alternative solution to the mainly used offering similar benefits:*** *Sometimes the characteristics of some individuals prevent them from using products or services in the usual way. A non-discriminating alternative offering equivalent results is then advisable.*

Despite DfA is *conceptually* based on the term *for all* and concentrates on equality in its definition, such strategies only concentrate on equal usability at the expense of equal accessibility and harmonizability. Additionally, it concentrates only on the human diversity resulting from effects of all personal factors and doesn’t completely imply the environmental diversity resulting from effects of all environmental factors. Thus, it may be considered a *human-sensitive* approach. On the applied level, the majority of case studies in the publication of *Diseños para todos* 2008 and 2010 confirmed the same orientation.

As opposed to UD, the proposed strategies allow for solving all needs without a single solution fitting everyone; one or more of them could be followed. They respect *practicality* by depending on a design space (diverse solutions) for *inclusiveness*.

'Design for equal usability' compared to DfA: On the *conceptual* and *applied*[1] level, and with the common goal of inclusion regarding usability, while *design for equal usability* is a *context -sensitive* approach by focusing on the human and environmental diversity in all their aspects related to the use relation, DfA is a *human-sensitive* approach by focusing only on the human diversity. While the *design for equal usability* seeks to integrate all people whatever their contexts (personal and environmental characteristics), the DfA seeks to integrate all people whatever only their personal characteristics. So, DfA isn't complete enough to be a *context -sensitive* approach considering equity with respect to usability.

On the *realm* level, exactly like *design for equal usability*, DfA targets the whole realm of designed things – all kinds of designed things; according to EIDD Stockholm Declaration, it targets '*everything that is designed and made by people to be used by people*'.

On the *methodology* level, and with the common goal of inclusion regarding usability, both DfA and *design for equal usability* give the freedom to create when it's inevitable a design space (diverse solutions) that can adapt, morph, or stretch to address each design need presented by *similar human characteristics*. Both set *practical limits* or respect practicality to achieve their aim of *inclusiveness* by not depending only on the *one-size-fits-all* solution.

Finally, regarding usability, although the above similarities, it can be concluded that *design for equal usability* is broader and more holistic and inclusive than DfA because of its comprehensive sensitivity to the context.

2.12.2.3. Inclusive design – in the UK:

The term *inclusive design* is mostly used in the UK; it bears similarities to UD and DfA, but with the requirement to also include the concept of *reasonable* (Persson, H.: 2014, p. 509) and *variety of situations* in its most noted definition defined (2005) by British Standard in the 6th part of the BS 7000 series as '*the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible on a global basis, in a wide variety of situations and to the greatest extent possible without the need for special adaptation or specialized design*' (BS 7000-6: 2005).

[1] – see the case studies of *Diseños para todos* 2008 and 2010

On the *conceptual* level, the phrase *reasonably possible* expresses one of the main differences from other approaches, since *reasonably* seems to suggest that the inclusion of – for example – people with disabilities can be disregarded if considered too difficult to achieve or too costly (Persson, H.: 2014, p. 509), whereas the United Nations Convention on the Rights of Persons with Disabilities – effective since May 2008 – claims these rights to be absolute and unconditional (UN: 2006). Inclusive design has its own very clear limitations; the practical limitations and economics of production and distribution processes, technologies and design innovation will mean that a small, but significant minority will be excluded (Cassim, J.: 2007, Towards inclusion, p. 230). Here we can say that inclusive design sacrifices the absolute inclusiveness based on the *one-size-fits-all* solution in favour of practicality. In turn, this gives way to relying on a design space (diverse solutions) *when it's inevitable* to ensure *inclusiveness* and *practicality*.

Also, for the first time, the phrase *variety of situations* defines one of the main differences from other approaches via concerning with the whole contextual characteristics of people (the environmental characteristics besides the personal characteristics).

Additionally, on the *conceptual* level, despite *inclusive design* is based on the term *inclusive*, it concentrates only on equal usability and accessibility in its definition at the expense of equal harmonizability. On the *details* and *applied* level, all efforts have concentrated only on equal usability – especially regarding the human side – perhaps because accessibility may be guaranteed in the UK or it's still synonymous with usability. For example, the efforts of the Inclusive Design Group of the Engineering Design Centre at Cambridge University clearly represented in the *Inclusive Design Toolkit* and of the Helen Hamlyn Centre for Design at the RCA confirm and go with the same orientation. So, while it may be considered a *context-sensitive* approach on the conceptual level, it may be considered a *human-sensitive* approach on the details and applied level.

'Design for equal usability' compared to inclusive design: On the *conceptual* level, and with the common goal of inclusion regarding usability, both *design for equal usability* and *inclusive design* are *context-sensitive* approaches focusing on both the human and environmental diversity in all their aspects related to the use relation. On the *details* and *applied* level, and compared to *design for equal usability*, *inclusive design* isn't complete enough to be a *context-sensitive* approach considering equity with respect to usability.

On the *realm* level, while *inclusive design* only targets products and services, *design for equal usability* targets the whole realm of designed things (products, services, systems, environments and technologies).

On the *methodology* level, and with the common goal of inclusion regarding usability, both *inclusive design* and *design for equal usability* give the freedom to create when it's inevitable a design space (diverse solutions) that can adapt, morph or stretch to address each design need presented by *similar contextual characteristics*. Both set *practical limits* or respect *practicality* to achieve their aim of *inclusiveness* by not depending only on the *one-size-fits -all* solution.

Finally, regarding usability, although the above similarities, it can be concluded that *design for equal usability* is broader and more holistic and inclusive than *inclusive design* because of its comprehensive sensitivity to the context on the *details* and *applied* level, and its broader realm.

3. Design exclusion and accessibility

3. Design exclusion and accessibility

3.1. Introduction:

With having the ability to use and harmonize with a designed thing, some people and sometimes people's segments find difficulty in accessing it or are unable to access it. As a consequence, their needs – sometimes the basic ones – may not be met. This means that their needs haven't been included in the scope of design practices or addressed through the design process; i.e. these people were vulnerable to design exclusion regarding accessibility.

For instance[1], 'while one part of the world sustains a designer bottled-water market that generates no tangible health benefits, another part suffers acute public health risks because people have to drink water from drains or from lakes and rivers shared with animals and infected with harmful bacteria' (UNDP: 2006, p. 35). Also, in the same society or country, although there are many available types of marketable water filters designed to support areas already having a potable water supply, unfortunately, there aren't available designed ones or even other alternative safe solutions for the rural and poor urban areas, where people don't have access to potable water to meet their basic water and cooking needs. In other words, there's a lack of designed tools that help access to clean water in remote areas, where there's no infrastructure for potable water supply.

Another abominable example comes from Egypt, while almost 40% of the population in 2005 was in the embrace of poverty (WB: 2007, p. iii), and a part of them lived in informal poor urban settlements (squatter communities) and cemeteries areas, most real estate investments have been addressed to the construction of apartments and villas in luxury compounds with lakes, gardens and vast golf playgrounds (Salah, H.). Huge housing projects comprising thousands of housing units at exorbitant prices target specific classes of the Egyptian society that already have many units. It's a clear example of wasted efforts and misleading development. The same condition happens in most noted Egyptian furniture exhibitions, in which, exhibitors address middle- and high-status classes of the society.

[1] Other examples are shown in section 3.5.

Also, in the same society, some designed things are expensive and aren't available in other cheap forms or alternative solutions. The cost of a designed thing is sometimes prohibitive; e.g. the purchase of a recent smart TV may be financially challenging for one family, while posing no financial stress for another.

Actually, many of the designed things are directed to specific individuals, groups or societies without considering the others. Thinking about this, the previous people have been excluded partially or totally from the mainstream of accessing the above-mentioned designed things. Actually, everyone may be vulnerable to finding difficulties in accessing some designed things or be unable to access them, and may be annoyed. Here, the most difficult moment is when someone feels inferior in front of a designed thing because he/she can't access it, or from the unwelcoming looks of some sellers when he/she tries to enter a shop or touch a designed thing – especially in brand shops.

Easy-to-access (easily accessible) designed things are pleasurable and satisfying to access, while those that are *difficult-to-access* will cause frustration for many people and exclude some altogether. The emotions coinciding with accessing a designed thing could be classified as *access-induced emotions*[1] which in turn affect the *access-induced acceptability*[2] and *desirability* of an individual toward this thing.

Now, the question is, *why are the aforementioned people exposed to these situations?* And *what does this mean?* Simply, the reason is that these things placed high access demands on these people; profoundly, the reason is that some matters related to the access relation haven't been considered throughout the entire design process; thus, a satisfactory level of accessibility isn't achieved for all people.

Accessibility (the ability of access) is the extent to which a designed thing can be accessed by specified persons to achieve specified goals. An accessible designed thing for an individual means that he/she has the ability, right or permission to get to it, or that access-related characteristics of his/her context are considered.

[1] Access-induced emotions are those induced by the efficiency of access.

[2] Access-induced acceptability forms with use- and harmony-induced acceptability the whole acceptability and the whole desirability toward a designed thing.

Actually, while many designed things may be *equally* created to be *easily accessible*, the ability to purchase or access them isn't always equal among all persons and populations. Here, we aren't going to discuss if *accessibility* hasn't been considered while designing things or not. It's a main consideration, and couldn't be ignored in the entire design process. Here, the study is concerned with how *profound* and *equitable* is the *accessibility* considered while designing things? Aiming to optimize accessibility for the largest number of persons or populations, the following debate is concerned with concluding, first, what isn't recognized and considered while design is practiced and negatively affects the quality of *accessibility*; and second, what isn't recognized and considered and makes the accessibility level of a designed thing low or nonexistent for some, or not equal among people or populations[1].

This requires detailed anatomy of the *individual-designed thing relation of access* through which it could be determined what should be recognized and considered for reaching a high level of accessibility and ensuring it for a high percentage of persons and populations for a long time. The following shows the required detailed *anatomy of the access relation*.

3.2. The access relation:

Regarding our point, *the current state of an individual's ability of accessing a particular designed thing* is a result of the interaction between *the current state of his/her empowerment abilities related to accessing it* and *the current demands of accessing it*; i.e. between the state of the individual's empowerment abilities related to accessing this thing and the demands of accessing this designed thing within a particular environment and in a specific moment. The 1st is derived from *the individual's empowerment-related characteristics* related to accessing this thing, and the 2nd from *the current access-related characteristics of the designed thing* which are made up from the features of some factors such as availability, price, affiliation (associated with an organization – a brand or a selling point), and availability of after-selling services – fig. 3.1.

[1] The following debate is concerned with to what extent 2 main matters are actually well recognized and considered throughout the entire design process of a designed thing. The 1st matter is the pillars and aspects of the access relation controlling the *quality of accessibility*. The 2nd matter is the diverse and dynamic contexts of access (*diversity* and *dynamism* of who accesses and where this thing is accessed) resulting in diverse values of these pillars and aspects, and controlling the *quality of coverage* (the number of the persons and populations who experience a satisfactory level of accessibility while accessing this thing) and the *quality of continuity* with a satisfactory level of accessibility.

Ease of access for an individual arises when the current demands of accessing a particular designed thing fall behind or at least are equal to the current state of empowerment-related characteristics of this individual related to access. Difficulty or inability of access (both express *design exclusion*) arises when the current demands of accessing a particular designed thing exceed the current state of related empowerment-related characteristics of this individual. At worst this difficulty leads to the individual being unable to access the designed thing; at best the designed thing may be difficult or frustrating to access.

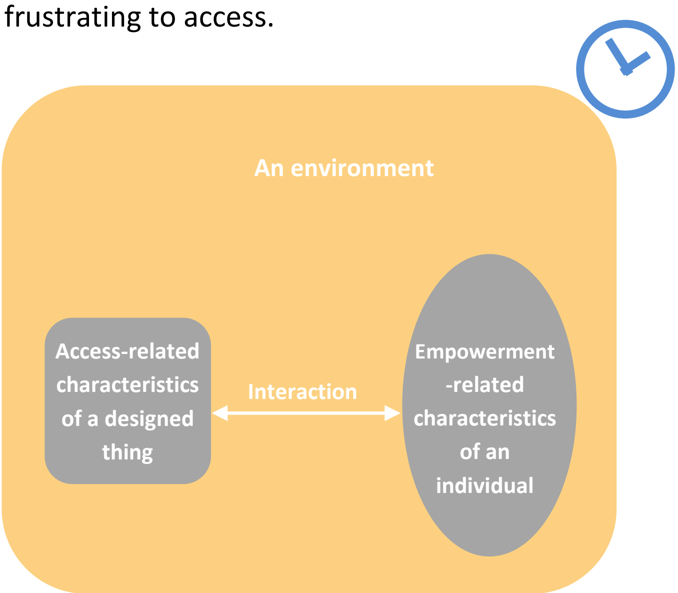


Fig. 3.1: A simple model of the access interaction between an individual and a designed thing.

According to this interaction relation of access, the ability state of accessing a designed thing ranges from full functioning to full disability (from finding ease, to having a little difficulty, to having more difficulty, to being unable to access the designed thing). While the functioning of accessing a designed thing is an umbrella term for the positive aspects of the interaction, the disability of accessing a designed thing is an umbrella term for the negative aspects.

From the above, *in a specific moment*, 3 pillars are controlling the access relation or the current level of the individual's ability of accessing a designed thing. The 1st pillar is *the current state of the individual's empowerment-related characteristics related to accessing the designed thing*, and it reflects the effects of the personal factors related to the access relation on his/her characteristics. The 2nd pillar is *the current state of the access environment characteristics related to accessing the designed thing*, and it reflects the effects of environmental factors related to the access relation on its characteristics which in turn affect the individual-designed thing interaction of access. The 3rd pillar (*the critical pillar*) is *the current state of access-related characteristics of the designed thing*, and it reflects the intention of the design project (the actors' intentions – of who practice, commission or manage design).

Looking deeper, *in a specific moment*, the current state of an individual's ability of accessing a designed thing is a reflection of to what extent the first 2 pillars are taken into account when the current state of access-related characteristics of this thing (the critical pillar controlled by actors) are determined. In other words, it's a reflection of to what extent the impacts of this individual's personal and environmental factors (contextual factors) on the first 2 pillars respectively, are considered when the 3rd pillar is determined.

To avoid *design exclusion* regarding access for targeted persons or populations, or to ensure that the current demands of accessing a particular designed thing don't exceed the current state of their empowerment abilities, requires considering the impacts of this individual's contextual factors on the first 2 pillars**.** In turn, it requires complete awareness of the contextual factors related to the access relation, and how they affect the first 2 pillars and thus affect the current level of an individual's ability of accessing a designed thing.

3.3. Contextual factors related to the access relation:

3.3.1. The consumer – The personal factors related to the access relation or empowerment:

A consumer of a designed thing is a person who has the ability, right or permission to get to it. The consumer as a human is an integrated context of numerous personal factors whose current features (absence, presence, values and/or qualities) make up his/her corresponding characteristics related to body, *skill*, *empowerment* and *ideology* which in turn make up his/her psychological and attitudinal characteristics. Personal factors refer to all aspects of the internal world that partly[1] form the context of an individual's life and, as such, have an impact on that person's functioning. Here, we are concerned with *empowerment-related personal factors* which represent the internal influences on the individual's ability level of *accessing* designed things – the impact of *empowerment-related attributes* of the person targeted to access (WHO: 2001, p. 11).

Personal factors related to the access relation include income and wealth, social status, political power, geographical location, knowledge, education and profession[2]. Own features

[1] The other part is the environmental factors that refer to all aspects of the external world – see section 3.3.2.

[2] knowledge, education and profession from the perspective of their effects on the person's empowerment – on the person's income, wealth, social status or political power.

of these personal factors make up the individual's empowerment-related characteristics, such as, urban and rural, central and peripheral/outlying/remote, sometimes northern and southern, sometimes western and eastern, rich and poor, with high and low income, and educated and uneducated, etc.

These factors can have a positive or negative impact on the 1st pillar '*the current state of the individual's empowerment-related characteristics related to accessing the designed thing*', thus, on the individual's ability of accessing designed things; and in turn, on the individual's participation in life activities. In other words, the personal factors may act as facilitators or barriers while an individual is trying to access a designed thing.

3.3.1.1. Dynamism – Changeability of the individual's characteristics related to empowerment:

Due to the reason that features of most personal factors related to empowerment are *changeable with time* – e.g. those being of income and wealth, social status, political power, geographical location, knowledge, education and profession; an individual's characteristics related to empowerment may change. Changes may happen slowly or quickly, regularly or irregularly, and may range from minor to radical. Actually, the changeability of the characteristics (*dynamism*) of an individual readily takes place. Hereby, on an individual's level, changes in the empowerment-related characteristics of an individual may have a different impact (may be dramatic) on his/her ability of accessing a particular designed thing; e.g. positive changes in a man's income affect in some way his ability of accessing a private car.

3.3.1.2. Variety and plurality of the potential consumers regarding empowerment-related characteristics:

Each person has his/her own empowerment-related characteristics resulting from his/her current features (absence, presence, values and/or qualities) of the corresponding personal factors. These characteristics *distinguish* people from each other and express the extent of differences among them. Differences in these characteristics among people may range from very low to very high. In turn, these differences among people may lead to corresponding differences in their abilities levels of accessing related designed things or their participation in some life activities. *Diversity* of the people – being already *dynamic units* – regarding characteristics related to empowerment is an indisputable fact. *Dynamic diversity* of the people in such characteristics is an essential aspect that must be considered while designed things are created. Closely related to social issues is the reality of differences of people's characteristics related to empowerment. Such differences result in what is known as class differences. Class differences in and among societies – common in earlier centuries – still exist in different parts of the world; differences in such characteristics result in classes of unspoken privileges and denial (Ashok, M.: 2009, p. 4-9).

Due to the reason that most designed things are created not to be accessed by a specific person or a group, and not to be accessed in a specific environment[1], plurality/plenty of people – being already *diverse* and *dynamic* – who may access a designed thing or copies of it, readily takes place.

3.3.2. The access environment – The environmental factors related to the access relation or empowerment:

The access environment of a designed thing is a medium in which the *individual-designed thing interaction of access* takes place. Like all environments, it's an integrated context of the numerous environmental factors whose current features (absence, presence, values and/or qualities) make up its corresponding *physical*, *social* and *attitudinal* characteristics. Environmental factors refer to all aspects of the external or extrinsic world that partly[2] form the context of an individual's life and, as such, have an impact on that person's functioning (WHO: 2001, p. 213). Here, we're concerned with *empowerment-related* environmental *factors* which represent the external influences on the individual's ability level of *accessing* designed things – the impact of *empowerment-related attributes* of the access environment.

Such factors include the natural physical world, the man-made physical world, support by others, external attitudes and values, and finally services, systems and policies (rules and laws)[3]. They can have a positive or negative impact on the 2nd pillar '*the current state of the access environment characteristics related to accessing the designed thing*'; thus on the individual-designed thing interaction of access; in turn, on the individual's ability of accessing this thing and on his/her participation in life activities. In other words, such factors may act as facilitators or barriers while an individual is trying to access a designed thing.

[1] In a world where most designed things have moved across borders, there's a sheer increase in the number of diverse access environments in which a copy of a designed thing may be accessed. Nowadays, countless copies of a designed thing are being accessed by different people in different environments.

[2] The other part is the personal factors that refer to all aspects of the internal world – see section 3.3.1.

[3] The appendix '*Environmental factors types*' provides more information.

Briefly, the following shows the effects of such factors on the people's abilities of accessing designed things:

- **The natural and man-made physical world:** It may affect the individual's ability of accessing a designed thing via facilitating or hindering the access of what is already available and affordable to access. For example, hurricanes, floods and the absence of transportation may hinder an individual from accessing some products and services.
- **Support by others:** Here, it's any support provided by others that changes the individual's level of accessibility. For example, humanitarian monetary aids offered by individuals, organizations or governments may increase the financial ability of a man, which in turn empowers him to access a designed thing; also, the aid may be the designed thing itself.
- **Policies:** They may positively/negatively affect the individual's ability of accessing a designed thing via controlling the availability of such a thing. For example, some countries don't adopt policies that help provide slaughter products according to the Islamic and Jewish rules, some prohibit the manufacture or import of spirits and sexual tools, some prohibit Internet services or limit them, and some prohibit the import of some products due to political or economic reasons.
- **External attitudes**[1]: They are those of people external to the individual whose situation is being described. Negative or positive practices of people (individuals or society) – resulting from their negative and positive attitudes respectively – towards an individual based on matters related to his/her characteristics, his/her abilities levels related to accessing, using or harmonizing with a designed thing, or his/her abilities levels related to accessing, using or harmonizing with this thing as compared to others, may negatively or positively affect this individual's ability of accessing this thing. Some people and societies *marginalize* some people based on their *body*-, *skill*-, *empowerment*- or *ideology*-related characteristics and prevent them from accessing some designed things. For example, some luxury residential compounds, clubs and schools stipulate specific characteristics with regards to the level of social status and education of their members. Also, for a period, Tchibo Mobil – a German telecommunication service provider – prevented foreign residents of specific nationalities from having access to its services, while some beaches and swimming pools prevent women and girls with the Islamic swimsuit (burkini) from accessing them.

[1] See the appendix '*Environmental factors types*' provides more information about external attitudes – no. 5.

3.3.2.1. Dynamism – Changeability of the access environment characteristics related to empowerment:

Due to the reason that features of some environmental factors related to empowerment are *changeable with time*, empowerment-related characteristics of an environment may change. Changes may happen slowly or quickly, regularly or irregularly, and may range from minor to radical. Actually, the changeability of the characteristics related to empowerment (*dynamism*) of an access environment readily takes place. Hereby, on an individual's level, changes in the empowerment-related characteristics of a particular environment may have a different impact on (may be dramatic) a person's ability of accessing a particular designed thing. For example, positive changes in practices of Tchibo Mobil towards foreign residents of specific nationalities with regards to preventing them from having access to its services, positively affect such residents' ability of accessing its telecommunication services.

3.3.2.2. Variety and plurality of potential access environments regarding empowerment -related characteristics:

Each access environment has its own physical, social and attitudinal characteristics resulting from the current features (absence, presence, values and/or qualities) of the numerous environmental factors. Such characteristics *distinguish* access environments from each other and express the extent of differences among them. Differences in these characteristics among environments may range from very low to very high according to differences in their own features of the same environmental factors. *Diversity* of the access environments – being probably *dynamic units* – regarding characteristics related to the access relation is an indisputable fact. In turn, differences in such characteristics among access environments may lead to corresponding differences in abilities levels of accessing a designed thing or participating in related life activities. On an individual's level, different access environments may have different impacts on the access ability of the same individual while trying to access the same designed thing or other copies of it in these different environments. An environment with barriers, or without facilitators, will hinder the individual's access; other environments that are more facilitating may increase his/her access. On the collective level of individuals, and with excluding things designed for access in specific environments, countless copies[1] of a designed thing are being accessed by different people in different environments which

[1] In a world where most designed things have moved across borders, there's a sheer increase in the number of diverse access environments in which a copy of a designed thing may be accessed.

may have different impacts on the people's abilities of accessing them. *Dynamic diversity* of the environments regarding characteristics related to empowerment is an essential aspect that must be considered while designed things are created.

Due to the reason that most designed things are created not to be accessed in a specific environment, plurality/plenty of access environments – being already *diverse* and probably *dynamic* – in which a designed thing or copies of it may be accessed, readily takes place; in a world where most designed things have moved across borders, there's a sheer increase in the number of diverse access environments in which these things are accessed.

3.3.3. Conclusion:

To conclude the former debate regarding the contextual factors related to the access or empowerment relation, it could be briefly stated that:

1. The personal and environmental factors related to the access relation or empowerment play a significant role in the individual's ability level of accessing a designed thing, and in his/her participation in related life activities. These factors can enhance or hamper the *individual's access experience*. This reflects the importance of such factors in the wider context of *individual-designed thing interaction of access*.
2. Regarding empowerment-related characteristics, the individual is *a dynamic unit*; his/her empowerment-related characteristics are *changeable with time*. In turn, changes in such characteristics may differently impact his/her ability of accessing a particular designed thing even if in the same environment.
3. According to the own features of personal factors related to empowerment, people are *diverse* in their characteristics related to empowerment. In turn, differences in such characteristics among individuals may lead to corresponding differences in their abilities levels of accessing designed things and participating in their related life activities. Also, the *plurality* of people – being already *diverse* and *dynamic* – who may access a designed thing or copies of it, is a permanent occurrence. The *dynamic diversity* of people in such characteristics is an essential aspect that must be considered while designed things are created, and the *plurality* of the possible people who may access them makes it more essential and challenging.
4. Regarding empowerment-related characteristics, the access environment is sometimes *a dynamic unit*; its empowerment-related characteristics are *changeable with time*. In turn,

changes in such characteristics may differently impact an individual's ability of accessing a particular designed thing in this environment.

5. According to the own features of the numerous environmental factors, access environments are diverse in their characteristics related to empowerment (physical, social and attitudinal characteristics). In turn, different environments, in which a particular designed thing is intended to be accessed, may lead to corresponding differences in an individual's ability level of accessing this thing and participating in its related life activities. Also, the *plurality* of access environments – being already *diverse* and probably *dynamic* – in which a designed thing or copies of it may be accessed, is a permanent occurrence. The *dynamic diversity* of access environments in such characteristics is an essential aspect that must be considered while designed things are created, and the *plurality* of the possible access environments makes it more essential and challenging.

6. The *dynamic diversity* of potential access contexts poses a serious challenge to equal accessibility and consequently to human and sustainable development.

3.4. What should actors and design practices consider?

Actors should keep in mind that

- overlooking partly or totally the effects and their extent of the *contextual factors related to empowerment* on the individual's ability level of accessing a designed thing;
- limiting the affecting personal factors related to empowerment to income and wealth;
- overlooking the *changeability* of most of the individual's characteristics related to empowerment and its *varying impact* on his/her ability of accessing the same designed thing;
- overlooking the *diversity* of the possible individuals in their empowerment-related characteristics and its corresponding *diversity* in their abilities levels of accessing the same thing;
- overlooking the *plurality* of the possible individuals being already *diverse* and *dynamic* in their empowerment-related characteristics;
- limiting the affecting environmental factors related to empowerment to the physical ones;
- overlooking the *changeability* of the access environment characteristics related to empowerment and its *varying impact* on the individual's ability level of accessing the same thing;

- overlooking the *diversity* of the possible environments in which a designed thing or copies of it might be accessed, and its corresponding *diversity* in the individual's ability level of accessing the same thing;
- or/and overlooking the *plurality* of possible environments in which this thing or copies of it might be accessed, and being already *diverse* and probably *dynamic* in their characteristics related to empowerment;

may at best lead to difficulty or frustration for some expected people while accessing this thing, and at worst lead to their inability to access it. In both cases, those people are vulnerable to *design exclusion*. Here, difficulties, frustrations and inabilities of accessing this thing (expressing design exclusion) don't come about by chance; they come about through the shallow understanding of the individual-designed thing relation of access, negligence, ignorance and lack of adequate information and data about *the potential people* who might access this thing or a copy of it and about the *potential access environments* in which this thing or copies of it might be accessed.

So, designing with *all effects and their extent of the contextual factors* related to empowerment on accessibility in mind helps create a thing that *may be well accessed*; and designing with *these effects*, *changeability of the consumer's and access environment characteristics*, and *the variety and plurality of the potential consumers and access environments* in mind helps create a thing that *may be widely well accessed (equally accessible) for a long time*.

While it would be strenuous to come up with all effects and their extent of all contextual factors on a consumer's abilities of accessing a designed thing, actors need to be aware of the maximal number of them. Also, while it would be impossible to come up with all various potential consumers and access environments of a designed thing and all changes that may occur with time in most of their characteristics related to empowerment, it's vital for actors to imagine typical and not so typical characteristics of the potential consumers and access environments for creating *realistic scenarios of access* for their designed things. Although it isn't possible to make all designed things easily accessible for everyone – for every access context, these realistic scenarios can help extend the accessibility of mainstream designed things and maximize the number of potential consumers.

3.5. Design exclusion regarding accessibility:

3.5.1. The status quo of social equity (equally meeting human needs) regarding accessibility:

Design exclusion regarding accessibility is commonplace. The status quo of meeting human needs implies that 'there are billions of people in abject poverty living in conditions where improving quality of life …., and thereby the potential for human development, remains a considerable challenge' (Fuad-Luke, A.: 2009, p.55). The majority of the world's population still struggles to maintain a *quality of life*, and is subject to food shortage, lack of potable water supply, poor sanitation, disease, homelessness, unsettlement and migration, conflicts due to resources shortage, and poor education systems, often coupled with socio-economic and political instability (ibid.).

According to the Human Development Report 2007/2008 conducted by UNDP titled *Fighting climate change: human solidarity in a divided world*, there are still around 1 billion people – roughly one-sixth of humanity – living at the margins of survival on less than US$1 a day, and 2.6 billion – 40 % of the world's population – living on less than US$2 a day and they account for 5% of global income; whilst the richest 20% accounts for 75% of world income (UNDP: 2007, p. 25). Around 10 million children die each year before the age of 5 – the vast majority from poverty and malnutrition, and around 28% of all children in developing countries are estimated to be underweight or stunted (ibid.). Poverty, hunger, easily preventable diseases and illnesses, and other related causes are silent killers. According to the United Nations International Children's Emergency Fund (UNICEF), 22000 children die every day due to poverty; and they die quietly in some of the poorest villages on earth (WB: 2008).

According to the Human Development Report 2006 conducted by UNDP titled *Beyond scarcity: power, poverty and the global water crisis*, some 1.1 billion people in developing countries have inadequate access to water, and 2.6 billion lack basic sanitation (UNDP: 2006, p. 2). While basic needs vary – the minimum threshold is about 20 litres a day, most of the 1.1 billion people categorized as lacking access to clean water use about 5 litres a day – one tenth of the average daily amount used in rich countries to flush toilets (ibid.: p. 5). Close to half of all people in developing countries suffer at any given time from a health problem caused by water and sanitation deficits, and 443 million school days are lost each year from water-related illness. Millions of women spend several hours a day collecting water (ibid.: p.

6). Almost 2 in 3 people lacking access to clean water survive on less than $2 a day, with 1 in 3 living on less than $1 a day; and more than 660 million people without sanitation live on less than $2 a day, and more than 385 million on less than $1 a day (ibid.: p. 7). Access to piped water in the household averages about 85% for the wealthiest 20% of the population, compared with 25% for the poorest 20% (ibid).

'Infectious diseases continue to blight the lives of the poor across the world. An estimated 40 million people are living with HIV/AIDS[1], with 3 million deaths in 2004. Every year there are 350 – 500 million cases of malaria, with 1 million fatalities: Africa accounts for 90 percent of malarial deaths and African children account for over 80 percent of malaria victims world-wide' (UNDP: 2007, p. 25). Based on enrollment data, about 72 million children of primary school age in the developing world weren't in school in 2005 (UN: 2007, p. 11); nearly a billion people entered the 21st century unable to read a book or sign their names (WB: 2008 and Shah, A.:2013); and 1.6 billion people – a quarter of humanity – live without electricity (ibid.).

According to the WB, in 2005, the wealthiest 20% of the world accounted for 76.6% of total private consumption, and the poorest fifth just 1.5%; the poorest 10% accounted for just 0.5% and the wealthiest 10% accounted for 59% of all the consumption (WB: 2008). The majority of the world (the *under-consumers*) needs to consume more to elevate their very basic standard of living, while the wealthiest 20% of the world (the *over-consumers*) use approximately 83% of the world's resources – a situation that most societies would recognize as grossly unfair (Fuad-Luke, A.: 2009, p. 55, 56).

The basic human needs – *physiological and safety needs* as envisaged by Abraham Maslow or *subsistence needs* as framed by Manfred Max-Neef, in their respective needs typologies – are met for this global minority (ibid.: p. 56). Under these conditions, quality of life remains an abstract expression; the majority is focused on survival, and striving to meet basic physiological needs (ibid.: p. 125). These people actually need to have access to appropriate technologies and resources; they need to consume more resources (ibid.: p. 125). Resources may be available locally or regionally but unequal distribution or consumption (by distant others able to access) of these resources, compounds local problems (ibid.: p. 125).

[1] Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome (HIV/AIDS)

'As many people in the world move into the underbelly of the world's cities, as rural populations grow increasingly disenfranchised and desperate, and as the world's poor struggle with disease, poor housing, and economic exclusion, they are not likely to look at the world of high-end consumption with indifference. This could be a recipe for increased violence and mass social breakdown.' (Appadurai, A.: 2008, p. 196)

3.5.2. Design exclusion regarding accessibility:

In many parts of the world, only the *higher-status* segments of societies – incl. the *higher -income* segments – have the chance to access designed things and benefit from them (Ashok, M.: 2009, p. 4-8). *Empowerment-related contextual characteristics* such as low social status, low economic status, and meager or nonexistent available opportunities create *barriers to access*. Regions, in which the higher-status segments of the population are the focus of designed things, create a situation in which people from all parts migrate to these regions to share in the benefit, while many groups of society from the region itself are neglected (ibid.: p. 4-9). In their groundbreaking article *The Fortune at the Bottom of the Pyramid*, Coimbatore K. Prahalad[1] and Stuart L. Hart[2] (2002) pointed out that there are close to 5.8 billion people whose *low purchasing power parity* has kept them from being targeted as *consumers* for whom products are produced and marketed (Prahalad, C.: 2002, p. 2, 4). Therefore, much like an iceberg with only its tip in plain view, this massive segment of the global population has remained largely invisible to the corporate sector (ibid.: p. 4). Tragically, capitalists have implicitly assumed that the rich will be served by the corporate sector, while governments and NGOs will protect the poor and the environment; this implicit divide is stronger than most realize, and we all suffer from this historical division of roles (ibid.: p. 14).

Referring to the above-mentioned status quo of meeting human needs, it's clear that the majority of the world's population still struggles to maintain a *quality of life* due to *access problems*. Thus, it may be concluded that the vast majority of the world population hasn't

[1] Coimbatore Krishnarao Prahalad (1942: 2010) was a professor of Corporate Strategy at the Stephen M. Ross School of Business at the University of Michigan.

[2] Stuart L. Hart is an American academic, writer and theorist, and the founder of Enterprise for a Sustainable World, a non-profit dedicated to *helping businesses make the transition to sustainability*.

been traditionally serviced by professional designers. This agrees with what Paul Polak[1] announced; he said: 'the majority of the world's designers focus all their efforts on developing products and services exclusively for the richest 10% of the world's customers.'

In 2007, a total of 337 design institutions nominated specific designs for the awards of *INDEX: Design to Improve Life*[2], for helping call attention to and encouraging greater involvement of the global design community in targeting the over- and under-consumers. In his book *Design Activism – Beautiful Strangeness for a Sustainable World* (2009), Alastair Fuad-Luke indicated regarding the winners that, 'unfortunately, only a relatively small proportion of the designs of the nominated winners in 2007 would be affordable to those earning a few US dollars a day, and the cultural acceptability of some of the designs remains a moot point' (Fuad-Luke, A.: 2009, p. 125, 126).

It can be concluded that the *existing design practices* are only serving specific segments in the same society or specific societies without serving the others. In this, those who access designed things are considered *elites*. The existing systems don't consider the *dynamic diversity of potential access contexts* (consumers & access environments) resulting from the effects of all personal and environmental factors related to the access relation. Simply, excluding people from accessing many designed things clarifies that many designed things haven't been equally created to access, or that the *dynamic diversity of potential access contexts* – in the same society or different societies – hasn't been included in the scope of design practices or addressed through the design process. The status quo demonstrates that poor design left many frustrated or facing difficulty, even if not excluded.

In general, the vulnerable to exclusion regarding accessibility (*under-consumers*) exists 'in the affluent societies of the North as well as the societies of the South' (ibid.: p. 125). They

[1] Paul Polak is the founder of International Development Enterprises (iDE) and has been recognized by Scientific American as one of the world's leading 50 contributors to science. After handing over iDE to new leadership, Polak started 2 new organizations, Windhorse International and design incubator D-Rev. He is also a member of the *Design for the other 90%* exhibition advisory council. Polak's book *Out of Poverty: What Works When Traditional Approaches Fail* has rapidly become the bible for anyone looking for practical solutions to global poverty.

[2] INDEX: Design to Improve Life® is a Danish NPO with global reach, established in 2002; now, it's known as The Index Project. The word INDEX was an abbreviation of INternational DEsign eXhibition. It *inspires*, *educates* and *engages* people to use design to improve the quality of life for everyone – to develop sustainable solutions to global and local challenges. (theindexproject.org/about)

are individuals, groups or segments within societies or sometimes form a whole society. Also, the *under-consumers* aren't only people who aren't able to afford or people in the bottom of the world economic pyramid, but they are all people who aren't able to access due to empowerment-related characteristics of their context. However, according to the aforementioned statistics, the majority of under-consumers are economically poor; they are either only poor or additionally characterized by other characteristics such as uneducated, rural, peripheral, marginalized, etc. Hence, it's logical to say that the *poor* represent the *majority of under-consumers*. In addition, empowerment-related characteristics of the context don't work only on the individual level but also on the community level, they may be characteristics of a group, society, country or region.

Most *under-consumers* live in rural villages, or urban slums and shantytowns, and usually don't hold legal title or deeds to their assets – e.g. dwellings, farms and businesses. They have little or no formal education and are hard to reach via conventional distribution, credit, and communications. The quality and quantity of designed things available for those *under -consumers* are generally low. They are waiting not only for the basic needs as food, textiles, and housing, but also high-tech ones such as financial services, cellular telecommunications, and low-end computers. They are often physically and economically isolated. (Prahalad, C.: 2002, p. 2, 4, 9, 14)

> *This is a good part of the reason for the single most important trend of the twenty-first century, which is the massive movement of people into very large cities, many of which are already characterized by deep inequality, serious disrepair in systems of governance and infrastructure, and high potential for crime and violence. Such megacities could contain more than sixty percent of the world's population by the year 2050, many of them in cities with populations in the range of 30 million.* (Appadurai, A.: 2008, p. 195,196)

Edward Glaeser pointed out that, cities attract poor people and the flow of less advantaged people into cities from Rio to Rotterdam demonstrates urban strength (Glaeser, E.: 2011). Half of the world's population now resides in cities, which are expanding at an unprecedented rate; close to 1 billion people live in crowded, unhealthy, informal settlements – known as slums or squatter settlements – which often lack security of land tenure, adequate housing, sanitation, clean water and electricity (Smith, C. E.: 2011). This massive urban migration is the leading challenge of this century pushing beyond the capacity of many local institutions to cope (ibid.). Experts estimate that number is projected to swell to 2 billion by 2030 (ibid.). Mostly, this situation is the output of economies that magnify the rich-poor division, global geopolitics and economics, political regimes that result in inequality and persecution, and disruptive man-made and natural disasters (Fuad-Luke, A.: 2009, p. 126).

The continuation of design practices to serve specific individuals, groups or societies without the others widens the gap among people rather than narrows it, which in turn may result in cracks among members and segments of the same society, and among societies. Differences in socio-positional status can create or contribute to rifts (Ashok, M.: 2009, p. 4-9), and increasing the state of inequality in and among societies negatively affects human and sustainable development.

The *drivers* for this are diverse but may hint at a lower order of priorities for a type of design considering under-consumers by the corporate sector – especially the multinational corporations (MNCs), a lack of funds for designers keen to work with the under-consumers, and a lack of ambition by many designers to work in this arena (Fuad-Luke, A.: 2009, p. 125).

Another *driver* that can't be ignored is designing through abstracted drawings and blueprints, rather than engaging directly with the *tangible contexts of access*. The creation of things has become an activity in which the yet-to-be-created thing is visualized through sketches, renderings, digital models and physical models. This lack of awareness through such a process can be seen as a contributing factor in the development of many unequal and unsustainable practices that are insensitive to the *realities of access contexts*.[1] (Walker, S.: 2006, p. 121)

3.5.3. Design exclusion regarding accessibility in a globalized world:

'There is a widespread and shared feeling that we are living in an era of globalization, of multinational business. …… *Globalization* is the process by which companies operate on an international level and socioeconomic patterns become adopted on a global scale. …… Spread of Western companies to new markets, particularly those in developing countries, began in the earnest with the worldwide recession of 1979' (McDermott, C.: 2007, p. 119). 'In the last

[1] Things created through direct contact with the realistic access contexts often possess qualities that speak of local knowledge, more complete awareness of people, place and materials, and a deeper and more immediate appreciation of their effects. (Walker, S.: 2006, p. 122)

century globalization was seen as the way forward, through increased international trade and the amalgamation of national markets' (ibid.: p. 120).

'There is mounting evidence that globalization increases wealth across the world but that it does not have salutary effects on equity and equality, within or between nations. Free trade, foreign direct investment, cross-border financial flows, and rapid sharing of technological innovations have not created a 'flat' world except insofar as the world's managerial classes are concerned.' (Appadurai, A.: 2008, p. 195)

Justifications to that are clarified in the next 3 points:

- 'Shifting of production to developing countries has led to the widespread exploitation of those countries in terms of trade and working conditions. …… Furthermore, unlike old-style multinationals such as Hoover, global companies such as McDonald's and Coca-Cola do not extract and process raw materials locally but simply exploit local markets' (McDermott, C.: 2007, p. 120). The pressures and opportunities of the global economy risk imposing a form of mass production excessively geared to commercial demands; such mass production threatens to impoverish many pillars of the receiving markets (UNESCO: 2009, p. 168); flooding traditional markets with Western industrial products has had a serious impact on (UNESCO: 2009, Executive Summary, p. 21) economies of local businesses, technologies, crafts and manufactured designed things. The spread of MNCs around the world is often accompanied by a breakdown of small-scale local businesses and the extinction of local technologies, crafts and designed things. These conditions reduce job opportunities, increase unemployment and reduce the GDP of the receiving countries, in turn, increase poverty, consequently the number of under -consumers, and widen the existing socio- positional gap in and among societies.
- Targeting intentionally the elites in developing countries by foreign direct investment widens the gap among classes in such countries; e.g. in Egypt, most real estate investment foreign companies target the high-status classes of the Egyptian society. Recently, the Egyptian government in the last 5 years was compelled to cover this gap – resulting in hundreds of informal poor urban settlements – by building approx. 1 million low- and middle-class apartments.
- Dealing with the cross-border markets similarly to the original market, regardless of the differences between them in access contexts, will lead to excluding some people regarding accessibility in cross-border markets. For example, countries such as the USA tend to develop

technologies that are well suited for their own consumers' access contexts without realizing the varying consumers' access contexts in different parts of the world (Ashok, M.: 2009, p. 4-8). What appears easily accessible to someone in the USA may be inaccessible to someone residing in a small village in the Egyptian poor countryside. Providing things designed for high-status societies (having high empowerment abilities) to low-status societies, will only address the elites of such low-status societies, which in turn widens the gap among classes in low-status societies; e.g. the spread of brand shops around the world targeting specific classes of people.

Thus, for the world's low-status people, '*globalization* is still substantially an unkept promise, and in some cases, a broken contract' (Appadurai, A.: 2008, p. 195, 196). It leaves behind the lowest of the low-status and those who are unable to keep up with its accompanying changes as in the 2nd and 3rd justifications and increases their numbers as in the 1st one.

The 2-pronged nature of globalization is seen here. On one hand, it helps greatly improve the economic status of societies, and allows nations to work with one another, learn from each other and participate in economic, educational and political transactions with each other; on the other hand, it leaves behind the low-status (Ashok, M.: 2009, p. 4-8)[1]. While proponents of globalization present a strong argument citing the benefits of the free flow of trade, finance and people, others perceive it as widening the current gap *regarding empowerment* in many societies (ibid.).

> *However, a growing coalition of environmentalists, anti-poverty campaigners, trade unionists and anti-capitalist groups see the growth of global companies as creating more problems than it solves. Their dissatisfaction with globalization lies in the fact that it has been of advantage only to the Western world.* (McDermott, C.: 2007, p. 120)

Actually and via the previous statistics expressing the reality in our globalized world, still only some segments in many parts of the world have the opportunity to access the mainstream designed things and benefit from them. It reveals that design practices within the era of globalization – extended for more than 3 decades – are continuing to serve intentionally or unintentionally specific segments around the world without the others, which in turn widens the gap among segments of the targeted societies. Intentionally is through targeting specific

[1] This sentence is derived from another different context.

segments in specific outside markets, but how has it been unintentionally? In a globalized system, when head offices are located in North American or European cities; resources are extracted, processed, formed and assembled somewhere else; and designed things are accessed and used somewhere else; some actors inevitably lack a full appreciation of the consequences of their actions. Within this system, information becomes filtered down to the essential but abstracted data of production performance, unit costs and profits (Walker, S.: 2006, p. 167). This creates a world of mediated experiences and produces a system that is increasingly divorced from the *realities of people's access contexts regarding empowerment* (ibid.). A more holistic understanding of the meaning of decisions and their impacts is lacking because there's little direct connection with people (ibid.).

With the fact that the overwhelming majority of the top 200 MNCs[1] are based in developed countries, it isn't surprising that MNCs' views of business are conditioned by their knowledge of and familiarity with the top of the world economic pyramid (Prahalad, C.: 2002, p. 4). Most MNCs automatically dismiss the bottom of the pyramid because they judge the market based on income, or selections of products and services appropriate for developed countries (ibid.). Actually, design within this system is far from the real recognition of the *majority's access contexts regarding empowerment*.

Finally, while the benefits of designed things are undoubtedly tremendous, such designed things in our globalized world, in some situations, contributed to the rift between the rich and the poor, the urban and the rural, and the educated and the uneducated (Ashok, M.: 2009, p. 4-8)[2]; the gap among people regarding empowerment has been increased by design practices under the globalized system. Globalization works as a supporter of unequal design practices. An overview of globalization and its impact on access to the mainstream designed things enlightens us with an understanding of social challenges for *equal accessibility* (ibid.)[3]. Thus, globalization presents both unprecedented opportunities and challenges (Appadurai, A.: 2008, p. 196).

[1] As we enter the new century, their combined sales equal nearly 30% of the total world GDP. (Prahalad, C.: 2002, p. 10)

[2] This sentence is derived from another different context.

[3] This sentence is derived from another different context.

3.5.4. Business and cross purposes:

The *core purpose* of a business is its most fundamental reason for being. By stripping away the layers of what a business does and what motivates it, any company will discover a deeper purpose that unifies and motivates. In essence, to discover a business core purpose, you could ask: Why does this business exist? Why does a business do what it does (designed things)? Purpose and values motivate and unify management and staff, give a company a solid foundation from which to make decisions, provide a navigational compass to all elements of the business, encourage loyalty of both staff and customers, and encourage a strong culture and ethos within a business. Also, customers will have more to buy into and engage with. All of this is a good reason for a business to look beyond profit.[1]

Rajat Gupta, CEO, McKinsey & Co. clarified this by saying, 'business is a force for good. It's a noble cause. To increase the performance of our clients helps create wealth and raises the standard of living around the world' (Spahn, J.: 2003, p. 2).

Yet research indicates that businesses are *at cross purposes*. Relying on 2 separate researches, J. Jeffrey Spahn and Alfons Trompenaars found that about 50% of the executives in the USA believe that the purpose of business is to maximize shareholders' wealth, and that the social responsibility of business is to increase its profits. The other 50% see the purpose of business as contributing to the well-being of society either via meeting customer needs, developing people, promoting a cause or making the world a better place via its philosophy and action. Furthermore, interviews revealed that 'the necessary priority of profits often gets translated into the purpose of business without giving much consideration to a possible distinction between the two.' (ibid.: p. 4, 5)

Profit is an output and a symptom of success of achieving the core purpose of business; and any organization needs more purpose than profit to make it through[2]. Thus, the core purpose of a company isn't to make profit; profit is a means to another end and not an end in itself (Spahn, J.: 2003, p. 4).

The relation between profit and the core purpose of a business can be coined as a relation between the *self-interest* and the *common interest*, whether it's between an individual and a

[1] stockerpartnership.com/resources/articles/purpose-beyond-profit/

[2] stockerpartnership.com/resources/articles/purpose-beyond-profit/

group, a company and a society, or a country and the world. For example, the government leaders of a particular country tend to serve only the interest of its citizens (ibid.: p. 3).

Actually and via the previously mentioned realities regarding unequal accessibility – locally and globally, we are informed that the main noble purpose of business has been lost, profit often gets translated into the core purpose of business, and such a model controlling design practices has become dominant. Paul Polak pointed out that the mainstream thinking about businesses is that they rip people off and put them into poverty.

George Soros, a financier and one of the wealthiest people in the world, warned at the end of the last century that our system focusing on the needs of the self is likely to break down unless it's tempered by the recognition of common interest and not just individual interests (ibid.). For an entity to maximize its economic value it must be active in the whole system; only for short periods can individual results be increased at the expense of the system; everything in our world connects and interacts; and nothing functions in isolation (ibid.: p. 6).

3.6. Answering the questions:

The previous section *design exclusion regarding accessibility* generates a pressing question: *Is there an urgent need to change?* Here, it's acceptable to answer this question in addition to the 1st research question.

The 1st research question: What are the causes related to design practices that make design correlates with the *unsustainability state of the world* regarding the *social inequity in meeting human needs*? Or what don't design practices consider and contribute to the *unsustainability state of the world* regarding *social inequity in meeting human needs*?

Referring to the aforementioned statistics and realities in section 3.5 that can be invoked, and according to the status quo of humankind and propagation of the various types of poverty on a large scale, it's clear that the basic human needs haven't been satisfied collectively or globally on an acceptable level. Some basic needs of many people's segments of the world have not been included in the scope of design practice; many designed things can't be *equally accessible* and simultaneously experienced by the largest number of people. Design as a means serves only a small percentage of humankind by targeting specific groups in a society or specific societies. This informs that: first, the past and current economic, social and political systems have failed to adopt and/or create suitable types of satisfiers for this task; second, design practices serving under such systems haven't collectively provided what empower what fully and consistently meet people's needs on an acceptable level, or haven't collectively actualized the *noble social role* of design on an acceptable level. Thus, design has failed to nurture the process of equally meeting fundamental human needs on an acceptable level.

What is so often evident is that the actors haven't deeply considered the *diversity of dynamic access contexts* (consumers and access environments), because if they had, then the people wouldn't have to experience such problems and frustrations. Actually, design as a means has lost more of its social responsibility regarding *equity in meeting human needs* (the 2nd area of SRD). This failure to deeply consider the *dynamic diversity of people's access contexts* in design practices sets a *correlation between the existing design state and the unsustainability state of the world* regarding *social inequity in meeting human needs*.

This justifies us to acknowledge that *unequal design practices* or *not deeply considering the dynamic diversity of people's contexts characteristics in design practices* is a verified cause behind the phenomenon '*the correlation between design and the unsustainability state of the world*' specifically '*social inequity in meeting human needs*'. *Thus, we can acknowledge the validity of the 2 proposed research hypotheses answering the 1st research question.*

3.6.1. Revolution in design:

To regain *social* relevance, there has to be an effort to refine the *design theory* to address *equal accessibility* considerations and also to identify and address the weaknesses and failures of design in this area. So, just as Paul Polak called in 2007, nothing less than a *revolution in design* is needed to reach the majority. His clarion call seems worth reiterating today. We need to redefine design from a commercially driven discipline to one that's used to improve the quality of life for everyone[1].

Considering the above-mentioned statistics and realities in section 3.5, where the design considerations of *equal accessibility* have been previously overlooked, it's now impossible for design practitioners to continue to ignore them, and imperative to avoid treating all

[1] theindexproject.org/about

contexts as the same. Such statistics and realities deserve to be recognized and respected and pose a radical challenge to design. They increase the need to make changes in design practices so that design is sensitive to the *dynamic diversity of potential access contexts* (consumers and access environments) – regarding empowerment. They offer a rationale for a required new design approach for countering *design exclusion regarding accessibility*. Thus, the approach '*design for equal accessibility*' is here proposed as a part of the general approach '*equitable design*'. It isn't a new design style; it's a logical response to the previous set of critical changes which form a tsunami competing for attention in a world still newly awakened to a shared responsibility for sustainability.

3.6.2. Business and revolution:

Actually, the call for a *revolution in design* to ensure *equal accessibility* without an accompanying *revolution in business* – via which design is often practiced – would be unreasonable, inefficient and ineffective. Unfortunately, in most professional design practices, design serves commerce and commercialism (Chick, Anne: 2011, p. 70). So, it's impossible to be efficient in countering the deteriorated status quo of equal accessibility via businesses whose primary purpose of *design for the market* is creating designed things for *profit*; especially with the fact that well-intentioned NGOs, communities, some local governments (loaded with problems), entrepreneurs, and even multilateral development agencies are unable to completely fill the wide gap or to change the dire reality. Although 'NGOs and local businesses with far fewer resources than the MNCs have been more innovative and have made more progress in developing these markets' (Prahalad, C.: 2002, p. 14) – see section 3.8.5.1, the dire reality remains.

Businesses, especially large firms and MNCs with global reach and having the technological, managerial, and financial resources, can be nodes for building the complex commercial infrastructure[1] for the under-consumers. Also, they have a unique global knowledge base that they can transfer to other markets. Without businesses, the above-mentioned entities will

[1] Building a complex commercial infrastructure for the bottom of the economic pyramid – for the majority, is a resource- and management-intensive task. Developing equally accessible designed things requires significant research. Distribution channels and communication networks are expensive to develop and sustain. Large companies, especially MNCs, have the managerial or technological resources to create this infrastructure. (Prahalad, C.: 2002, p. 11)

continue to flounder in their attempts to bring *development* and *equal accessibility* to the disadvantaged. Businesses are best positioned to unite the range of actors required to develop the under-consumers' markets. (ibid.: p. 11)

For this, it requires a revolution in the dominant business paradigm/policies[1] – especially of the MNCs supported by governments. This revolution in business will open the way to the required revolution in design to come and to be effective.

This isn't a detraction of the above-mentioned entities role, but actually, they work as a white point in the darkness and they can't practically control design practices to reach the billions of people bypassed by current systems. According to their nature and capabilities – as social enterprises[2] – and to the historical reality, they can only work as pioneers, guides or activists, not as a savior of the *wicked problems*. Collectively, their work is useless if it doesn't work via a profitable supply chain or a long-term or sustainable solution, but via an unusual business model.

[1] – a revolution in how businesses design, price, market and distribute their designed things.

[2] A *social enterprise* is an organization that applies commercial strategies to maximize improvements in human and environmental well-being, rather than maximizing profits for external *shareholders* – social aims are primary and profits are secondary. Social enterprises can be structured as a *profit-for-purpose* (self-funded) or *non-profit* (funded by donations), and may take the form of a co-operative, mutual organization, a social business, or a charity organization. (Wikipedia: Social enterprise)

Social enterprise businesses are led by a mission to achieve social, community and environmental benefit via trading and by channeling a portion of their profits toward their mission. An example of a *profit-for-purpose* is Hepburn Wind, the owner and operator of Australia's first community wind farm located in Leonards Hill, Central Victoria. Profits generated from the sale of energy are reinvested into local community projects such as an indigenous garden, irrigation for local kindergarten and renewable energy educational programme. You might be surprised to learn that the shift towards self-funded '*not-for-profit*' businesses actually started with Oxfam in 1948, through the opening of its first charity shop. Proceeds from the shop were used to support Oxfam's efforts around the globe to find lasting solutions to poverty and related injustice. anthillonline.com/why-is-profit-for-purpose-so-darn-cool/

3.7. 'Design for equal accessibility' as a part of 'equitable design':

For countering *design exclusion regarding accessibility*, we have to base our designs on the principle of inclusion; so, the *design for equal accessibility* approach is proposed as a part of the *equitable design* approach. It refers to design based on a *context-sensitive* approach considering equity with regard to accessibility. The main goal of *design for equal accessibility* is to ensure that all people find what is accessible for participating in a specific life activity, achieving a specific task or satisfying a specific human need regardless of the contextual factors (personal & environmental factors) related to the access relation. It aims that no one should be excluded because of his/her *access context characteristics* related to the access relation. It aims to ensure and extend easy access for the widest possible people. So, it's a design approach that places the *dynamic diversity regarding empowerment* at the heart of the design process.

At the heart of *design for equal accessibility* lies a deeply human- and environment-sensitive focus on human and environmental dynamic diversity regarding empowerment respectively. Dynamic diversity concerns not only consumers but also access environments which are continuously developing and diversifying – see section 3.3. The related line of reasoning is that since both people and access environments are dynamic and diverse, thus, people have different accessibility requirements, and it's necessary to consider all of them in a *context -sensitive* design process.

So, *design for equal accessibility* is a more *holistic* approach seeking to consider the dynamic diversity of access contexts resulting from the effects of all contextual factors related to the access relation; in turn, this requires considering a *wider range of requirements*.

Transcending the traditional view of accessibility targeted toward specific people, groups and societies, *design for equal accessibility* embraces theoretical, methodological and empirical research that addresses accessibility in any context of access – i.e. by anyone, anywhere and at any time – or addresses the new demands for the dynamic diversity of access contexts for ensuring equally high-quality access interactions. This conceptual approach is shifting the actors' interest to real access contexts. It challenges the conventional approach and seeks to provide a design foundation for more *equally accessible design*.

Traditional efforts to provide accessibility for the excluded majority were based on the *reactive actions* of well-intentioned NGOs, communities, some local governments or multi-lateral development agencies seeking to protect them. Due to the essentially reactive nature of such efforts and their low effectiveness compared to the required, and with the current dire reality of the world – see section 3.5, the need for *systematic* and *proactive approaches* for equal accessibility has become inevitable.

The need for this approach is creating new challenges and opportunities for developing the mainstream designed things considering equal accessibility. In theory, this may appear to be a formidable challenge, but investing energy into achieving equal accessibility is a valuable effort. The challenge inherent in such an approach should be taken as an inspiration for *good design* and not an obstacle. Actually, designing everything to be equally accessible for every-one under all conditions is virtually impossible with a *one-solution-fits-all* – rarely can every designed thing achieve global easy access with a single solution (Ashok, M.: 2009, p. 4-8; Marcus, A.: 2009, p. 9-4; Vanderheiden, G.: 2009, p. 3- 13); even if so, is it practical or feasible? So, *design for equal accessibility* adopts the *one-solution-fits-all* as the main path and supports it with other paths to ensure *inclusiveness* and *practicality*.

Paths: Here, a set of *5 proposed paths* could be followed by those who practice and manage design to avoid *design exclusion regarding accessibility* to reach the billions of people bypassed by current design practices:

1. Reduce the level of ability required to access the designed thing as much as possible – reduce the designed thing demands – to achieve accessibility for an extended range of contexts; this expresses the *one-solution-fits-all* path; e.g. radically affordable solutions for people living under less than 2 $ a day – see also the examples of Brilliance (a world-class affordable phototherapy device), XO laptop (a rugged, low-cost, low-power and connected laptop), Remotion Knee (an affordable high-performance knee joint for amputees) and Virtual Office – section 3.8.5.1. Additionally, see Whirlwind Roughrider (a low-cost highly functional wheel-chair) – section 2.11.8.1.

2. Offer the designed thing in other modified versions; e.g. apartments, flats and houses of various spaces; a car model in different versions regarding size and options; and multiple size packages of detergents. Such examples affect the price and this makes the design more equitable – see also, the example of Wheel (an affordable detergent) – section 3.8.5.1.

3. Offer the designed thing via different access systems, such as *ownership* (new or used – cash /instant payment or instalment), *common ownership* and *paying-for-use* (rental systems in which the supplier remains the owner of the designed thing whether it's in the supplier's or the user's domination); e.g. the *common ownership* system such as a washing machine in the cellar serving all inhabitants of the building, and the *paying-for-use* system such as real estates and laundromat (self-service laundry) – see also, the example of Virtual Office – section 3.8.5.1.
4. Offer other *alternative solutions*; e.g. public transportation rather than private cars – see also, the examples of Q Drum (water transporter), LifeStraw® (affordable water filter), Ceramic Water Filter, Watercone®, Eco-Beam and sandbag system, 10 X 10 Sandbag House, Plastic Formwork System, Floating Community Lifeboats, Millennium School Bamboo project, Optare Alero CSV and Spring Health Water Ltd. – section 3.8.5.1.
5. As a last resort, *improve the context characteristics* (related to empowerment) of the under-consumers via the designed thing chain to avoid as much as possible customizing impractical special things for them; e.g. increasing the earning potential of the poor enables them to earn more and get the mainstream designed things – see also, the examples of Wheel detergent and Spring Health Water Ltd. – section 3.8.5.1.

The 5 paths can lead to diversity-supportive design and prove that equally accessible design is a realistic goal. Anyway, to achieve this goal, choosing the suitable path or paths will have to be established upon a careful trade-off among them based on functional and economic criteria.

While the first 4 paths could be classified as a *context-fit* path, the 5th could be classified as a *context-improve* path. The *context-fit* path adopts solutions offered to match the empowerment-related characteristics of the contexts of the under-consumers (poor, rural, peripheral or uneducated) to include them. The *context-improve* path adopts solutions offered to improve such characteristics to uplift the access abilities of the under-consumers. A simple example is to increase the earning potential of the poor via making them a party of the life cycle of the designed thing such as a participator in manufacture, producer, marketer and/or distributer of it – via revenue-generating activities related to the designed thing. It focuses on how the poor can become active members rather than simply consumers via helping them create small enterprises or makes them new entrepreneurs. This builds a permanent solution to poverty and the poor can earn more and improve their families' position in the class pyramid and stay out of poverty. Thus, this income-generating[1] thing would contribute to the social and economic development. Besides the purpose of its creation, such a thing should be designed with another purpose in mind: to help people and their families stay out of poverty.

Improving and preventing deterioration of the personal and environmental characteristics of people's contexts may uplift their capabilities and facilitate working on meeting their needs. Rather than working on fitting the contexts characteristics for making designed things fit with the people's capabilities to meet their needs, sometimes, it may be practical and better to improve the contexts characteristics.

While the 1st path (*one-solution-fits-all*) doesn't imply a separate, specialized or segregated solution, the 2nd to 4th show increasing levels of *customization*. While *segregated proactive* solutions weren't practical in the past, now, considering the current dramatic changes in the world – see section 3.5, *segregated proactive solutions may become more practical because they are arranged to come as an integrated part of the system*.

The 3rd path offering designed things through different access systems – *ownership*, *common ownership* and *paying-for-use* systems – is a multi-advantage path. The last 2 systems positively work on the environmental level and on ensuring accessibility for the majority of people. Both systems work on minimizing resource consumption, emissions and waste during the production, use and disposal stages (Vezzoli, C.: 2008, p. 203). Also, paying less to own a portion of a designed thing or for the real time of using it reduces the designed thing demands regarding empowerment, in turn, helps achieve equal accessibility of this thing. In addition, both systems facilitate equal access to the new, more 'in fashion' and more technological models of this designed thing.

---

[1] Income is a basic human need. The 1st need of the poor is a way to make money to be able to get food, water, shelter, medicine and other necessities. If you don't, you can't. The cause of poverty is a lack of money, so what a poor person needs most is a way to make more money. When you look past poverty, you see abilities, resources and desires. The poor are extremely hard-working and entrepreneurial; they must be just to survive. The poor aren't victims. They don't want or need to be rescued. They want an opportunity to create a better life for their families. (kickstart.org)

Large differences in income remain among regions, across countries in the same region, and within countries. (Chick, A.: 2011, p. 147)

Dynamic diversity requires diversity: *Design for equal accessibility* doesn't suggest that it's always possible to design a single solution to address the same needs of all people. Instead, it guides an appropriate design response to the diversity and dynamism of access contexts through following the aforementioned paths; i.e. through developing a *family* of designed things or derivatives to provide the best possible people coverage.

Also, it shouldn't be conceived as an effort to advance a single solution for everybody, but as a *context-sensitive approach* providing a family of solutions that can automatically address the possible range of contexts. Consequently, the outcome of the design process isn't intended to be a singular design, but a design space populated with appropriate alternatives, together with the rationale underlying each alternative, that is, the specific *access context characteristics* for which each alternative has been designed. (Emiliani, P.: 2009, p. 2-8, 2-17)

It's a process: Following alternative design decisions leads to diversity in the final design outcomes. Because of this, it may be more appropriate to consider the *design for equal accessibility* approach as a *process*, rather than an *outcome*. Such a process can foster innovation and improve design and it's likely to deliver a thoughtful design space populated with suitable alternatives (designed things) which ensure that all people find what is accessible for participating in a specific life activity or satisfying a specific human need – see successful case studies in section 3.8.5.1.

Equal opportunities: *Design for equal accessibility* works on enabling equitable access and equitable active participation of all people in human activities. It gives independence to all people and enables them to have equal opportunities to participate in every aspect of society; i.e. it helps liberate and enable people. It promotes the inclusion of all people in all life activities.

Definition: *Design for equal accessibility* can be defined as:

- ''the design of mainstream things to be accessible by as many people as possible even if through diverse solutions when inevitable.''
- ''the design that ensures accessibility for the widest possible people even if through diverse solutions.''
- ''the design that ensures that all people find what is accessible for satisfying a specific human need regardless of their different contexts.''

Thus, *equally accessible design is design that considers the full range of personal and environmental dynamic diversity of potential interaction contexts with respect to the access relation whether through a single solution when possible or diverse solutions when not.*

Localization: The *Design for equal accessibility* approach and its proposed paths point out that *localization* should be attendant *in some way* for equal accessibility; paths *not* following the *one-solution-fits-all* path (2nd, 3rd, 4th, and differently 5th paths) rely on localizing the solutions to fit specific contexts and similar (by *considering or/and improving* local conditions, reality or capabilities regarding access). Thus such an approach could combine *generalization* and *customization* in a design space. It adopts the *one-solution-fits-all* as the main path and supports it with other paths to ensure *inclusiveness* and *practicality*. Following such paths in praxis with considering small-scale local businesses and local culture, and/or relying on local people, businesses, technologies, crafts, designed things, resources and materials increases the attendance of *localization*.

Also, such an approach could put *localization* in the core of *globalization*, and combine both of them in a unique relationship. Considering the diversity of dynamic contexts regarding empowerment takes globalization and its accompanying dominant systems to another different perspective, from reaching everywhere to fitting everyone and from the dominance of ideas to the adjustment of ideas on the local levels. This corrects the path of globalization always replicating the Western system, and helps benefit from the massive power of globalization in the thinking process, and apply according to the local reality. This invites us to think globally, but design locally (Chick, A.: 2011, p. 145) via marrying global best practices with local capabilities, combining advanced technology with deep local insights, and bringing together the global resource base to address local conditions (Prahalad, C.: 2002, p. 6, 11).

Thus, the globalization path could be changed by acknowledging the value of the local, the diverse and the particular (Walker, S.: 2006, p. 127), and intensifying global social interdependencies or relationships between the local and the international (ibid.). This would seem to be at odds with the overwhelming globalization of corporations, communications and manufacturing that has been occurring in recent times and designed things that accompany such a development (Steger, M.: 2003, pp. 7: 13). For this, actors seeking to address the consequences of unequal accessibility – whether in the same society or among societies – need a clear sense of what they are trying to achieve (sensitivity to context) and how to go about it (the process of achievement).

The process of localizing a designed thing is an important balance to globalization. Here, it refers to considering the dynamic diversity of empowerment-related characteristics of specific contexts or markets to enable their people to find what is effectively accessible. To achieve effective localization of a designed thing, it's necessary to identify groups with similar contexts within larger groups of the population (Ashok, M.: 2009, p. 4-8).

An example of *localization* of a designed thing for a specific social group would be customizing single-serve packaging[1] of a detergent for the poor. The rich have the disposable income and the space to buy in bulk and shop less frequently; they use their spending money to inventory convenience (Prahalad, C.: 2002, p. 10). The poor strapped for cash and with limited living space, shop every day, but not for much; they can't afford to stock up on household items or be highly selective about what they buy; so, they look for single-serve packaging and easily switch brands every time they buy (ibid.).

SRD: By adopting the *design for equal accessibility* approach, design as a means would regain more of its lost social responsibility regarding *equity in meeting human needs* (the 2nd area of SRD model); in turn would decrease/alleviate the existing and possible gap regarding empowerment in and among societies. Through such a process aiming to achieve *equity in meeting human needs*, design may play another social role through approaching the *context -improve* path – i.e. through improving the underserved people's context characteristics related to empowerment to uplift their access abilities which facilitate working on meeting their needs. In this, design embraces the new recently emerged area of *SRD* concerned with tackling the complexity of the most pressing issues, such as unemployment and poverty, being actually *inhibitors* for features of the contextual factors that negatively affect the empowerment-related characteristics of people's contexts which should be considered for meeting their human needs. Improving and preventing the deterioration of such characteristics are actual resistance to the impacts of these *wicked problems*.

[1] – packaging for daily purchasing

This *holistic, innovative and socially responsible* approach constitutes a *creative and ethical challenge* for the design, business and decision-making communities. It completely places the *responsibility* on people who practice, commission or manage design to ensure equity regarding accessibility. The failure to achieve this requires *interventions* to ensure accessibility for those who are excluded.

Proactiveness: *Design for equal accessibility* is a *proactive approach* aiming to avoid exclusion regarding accessibility, avoid downstream problems resulting from exclusion, minimize the need for reactive actions (posterior adaptations or specialized designs), and deliver designed things that can be tailored for access by the widest possible people. Accordingly, this entails a forward-looking *proactive attitude* toward shaping new generations of things rather than short-/medium-term *interventions* on the present and market situation (Stephanidis, C.: 2009, Universal access and design, p. 1-2).

Required conscious efforts: *Design for equal accessibility* may be defined as a general framework catering for purposeful, conscious and systematic effort to *proactively* apply principles and methods and employ suitable tools to develop equally accessible design, thus avoiding the need for reactive actions (ibid.). Without conscious effort, it's very easy to exclude by design (Cassim, J.: 2007, Why Inclusive Design? p. 17, 18). To this end, the empowerment-related characteristics of the broadest potential consumers' contexts must be taken into account throughout the entire development life cycle of new designed things as early as possible (from the early design phase – conception, to design and release). Under this perspective, *design for equal accessibility* can affect the entire development life cycle of designed things.

To reach a successful and cost-effective realization of this vision, it's critical to ensure that suitable methods and techniques of a designed thing development are available. Traditional development processes, targeted toward specific individuals, groups or societies, are clearly inappropriate for addressing the new demands for *equal accessibility*. Classic design methods are suboptimal since they can't accommodate diversity and dynamism. Working in this area should concentrate on design and development frameworks, methodologies and tools that help deeply recognize and support the *design for equal accessibility* approach, and integrate the consideration of dynamic diversity of access contexts throughout all development phases. (Stephanidis, C.: 2009, Universal access and design, p. 1-5)

The best practices regarding *design for equal accessibility* will be those focusing on the *context-sensitive* and *process-oriented* nature of design. Main efforts in this direction are concerned with the identification and study of various non-mainstream target consumer groups (e.g. poor, rural, peripheral, uneducated, etc.), as well as of their requirements for interaction; the study of various potential access environments, as well as of their requirements for interaction; and the identification, design and development of appropriate frameworks, methods, techniques and tools that help deeply address the real needs according to the *design for equal accessibility* approach.

Promoting the message: To achieve *equally accessible design* requires considering the dynamic diversity of the potential access contexts in the design process; in turn, this entails that all actors (people who *practice*, *commission* or *manage* design) should acknowledge such an approach, i.e. acknowledge that diversity is the one true thing that contexts have in common, dynamism is an inevitable matter, and there are dangers of widening the accessibility-related gap among people of the same society or among societies. Considering the diversity aims to avoid the problems of excluding some potential people, and considering the dynamism aims to avoid future problems of excluding people who are already included. So, inspiring and nurturing a new generation of actors will be crucial for the future – for more inclusiveness and tolerance, and the most effective way of doing this is to encourage them to think about others and future or dynamic diversity rather than following unconsciously the *dominant business system* which intentionally or unintentionally serves specific individuals, groups or societies.

Acknowledging and adopting the dynamic diversity regarding the access relation by all actors requires promoting the *equally accessible design message* within the design, business and decision-making communities; i.e. it requires raising the awareness of all actors for changing their mindsets/attitudes to help adopt the *design for equal accessibility* approach. This could be achievable via providing sufficient reliable relevant knowledge (leading to real requirements), developing empathy towards the under-consumers (excluded majority), and eliminating the fears and doubts about such an approach. Here, some fundamental keys could be proposed for raising awareness needed to promote the *equally accessible design message* within the 3 communities or for those whom dynamic diversity regarding the access relation isn't on their radar:

- Building up the relevant literature
- Actively involving diverse potential consumers in the design process
- Working outside the served elites
- Creating realistic scenarios considering diverse potential access contexts – Scenarios
- Eliminating the fears – Motivations

These keys could raise the actors' awareness and help them improve the *majority's quality of life* through *equally accessible design* that promotes independence and social inclusion. To work well in raising awareness of all actors toward the *design for equal accessibility* approach, these keys suitable supportive frameworks and methods, and consequently appropriate techniques and tools – according to the *aimed actor*. The focus in the following section will be the rationale for these keys**,** and the positive impact that they can have on the aimed actors and the final design outputs.

3.8. How to promote 'design for equal accessibility'? – Fundamental keys:

3.8.1. Building up the relevant literature:

One of the most common ways to get information regarding any approach is the literature searches. A literature search involves reviewing all publications (readily available materials).[1] Reliable publications being relevant to *design for equal accessibility* would be a main source of the required knowledge for the design, business and decision-making communities (the actors); in turn, this may raise their awareness and change their mindsets/attitudes helping adopt the *design for equal accessibility* approach. Also, such publications may develop empathy towards the *under-consumers*, and eliminate the fears and doubts about this approach; in turn, this may change the actors' mindsets and be a powerful driver for them to consider needs beyond their own immediate experience based on *self-observation* or/and the *dominant paradigm of design* (serving intentionally or unintentionally specific segments around the world without the others). According to the aimed actor, information could be presented via many ways, such as curriculums, courses, workshops, seminars, symposiums, conferences, vocational training, coaching, periodicals, etc.

Building up the literature of *design for equal accessibility* approach for promoting it within the design, business and decision-making communities, isn't an easy mission. The nature of this approach based on equity and dynamic diversity requires huge, different complex information from different directions to form coherent literature. Also, some of this information should be constantly updated; such as statistical data about the distribution of the personal characteristics related to empowerment in the population.

Mainly, the literature content of the *design for equal accessibility* approach should cover the individual-designed thing relation of access (facts – accessibility, dynamic diversity); the *why, what and how* of *design for equal accessibility* approach; and the *how* of promoting its message within the design, business and decision-making communities. This literature should include:

[1] – for more information about literature searches, see section 2.11.1.

- Anatomy of the access relation
  - The contextual factors (personal and environmental factors) and their effects on the individual's ability of accessing a designed thing
- Dynamic diversity
- Design exclusion regarding the access relation
- Drivers (the new reality – statistics and critical changes) beyond the need to *design for equal accessibility* approach – section 3.5. They offer a rationale for the required new design approach aiming to counter *design exclusion regarding accessibility*. These drivers increase the need to make changes in design practices so that design is responsive to the dynamic diversity of the potential contexts.
- Reliable updated data and information about the target group or population
  - Reliable updated statistical data about the demography of the target group or population according to the *empowerment-related personal factors* (income and wealth, political power, social status, geographical location, knowledge, education, profession). National, regional and global statistics would be important and useful. Here, updating is a critical matter due to the continuous demographic changes.
  - Reliable updated design guidelines and standards regarding accessibility for the typical and not-so-typical *characteristics related to empowerment* of potential consumers – not-so-typical characteristics such as rural, peripheral, poor, with low income and uneducated. Here, updating is a critical matter due to the continuous changes in relative technologies.
- Reliable updated data and information about the potential access environments
  - Reliable updated statistical data about the demography of the potential access environments according to the *empowerment-related environmental factors*. National, regional and global statistics would be important and useful. Here, updating is a critical matter due to the continuous demographic changes.
  - Reliable updated design guidelines and standards regarding accessibility for the typical and not-so-typical *physical characteristics* of potential access environments. Here, updating is a critical matter due to the continuous changes in relative technologies.
- What is *design for equal accessibility*?

- Ways/paths of making designed things equally accessible or avoiding design exclusion regarding accessibility – examples of equally accessible designed things adopting these paths
- The origin of the *design for equal accessibility* approach and the similar proactive approaches
- Fundamental keys of putting *design for equal accessibility* on the actors' radar or fostering the *equally accessible design* message within the design, business and decision-making communities
- Frameworks, methods, techniques & tools developed and would be developed for achieving the fundamental keys promoting *design for equal accessibility* message within the design, business and decision-making communities – examples
- Guidelines for managing the adoption of or change to *equally accessible design* in the business policy
- Successful examples of *equally accessible* designed things on the design and business level
- Others

Any material belonging to the above-mentioned proposed points could form an effective stone in building the literature of *design for equal accessibility* approach. The importance level of any point varies according to the aimed actors to whom this point is directed; e.g. while materials about the commercial opportunities in the under-consumers' market, are of utmost importance to be directed to business management teams and decision-makers, they aren't of the same importance to be directed in-detail to the design community.

The quality of actors' decisions regarding equal accessibility depends on the availability of comprehensive and good data – especially updated statistics.

It's worth mentioning that materials of similar proactive approaches such as *inclusive design*, *DfA* and *UD* would be of importance.

The following list provides a short list of useful resources covering or including some materials belonging to the previous points:

Books such as[1]:

- *Universal design handbook* (Preiser, W.: 2011)
- *Universal design handbook* (Preiser, W.: 2001)
- *The universal access handbook* (Stephanidis, C.: 2009, The universal access handbook)
- *Design for inclusivity – A practical guide to accessible, innovative and user-centred design* (Coleman, R.: 2007, Design for Inclusivity)
- *Inclusive design: design for the whole population* (Clarkson, J.: 2003)
- *Countering design exclusion: An introduction to inclusive design* (Keates, S.: 2004)

Journals such as:

- *Diversity in design: The journal of inclusive design education*
- *The design journal*
- *Design studies*

Publications and proceedings of conferences such as:

- The international conference *include*, the Helen Hamlyn Centre for Design at the RCA, www.rca.ac.uk/research-innovation/helen-hamlyn-centre/knowledge_exchange/include-conferences/
- *The international conference for universal design*, by the IAUD, Japan, www.iaud.net/global/conference/
- The international conference on *design for inclusion*

Contents of websites such as:

- www.rca.ac.uk/research-innovation/helen-hamlyn-centre/ of the Helen Hamlyn Centre for Design at the RCA, London, UK
- www-edc.eng.cam.ac.uk/research/inclusivedesign/ of the inclusive design group at the Cambridge Engineering Design Centre, University of Cambridge, UK
- www.inclusivedesigntoolkit.com/ developed by the inclusive design group at the Cambridge Engineering Design Centre, University of Cambridge, UK
- https://humancentereddesign.org/ of the IHCD, Boston, US
- www.iaud.net/global/ of the IAUD, Japan
- www.universaldesign.com/
- https://projects.ncsu.edu/ncsu/design/cud/ of the CUD, NC State University, US
- http://idea.ap.buffalo.edu/ of the Center for IDeA, University at Buffalo, US
- https://idrc.ocadu.ca/ of the IDRC at the OCAD U, Toronto, Canada

[1] Full details of books are given in the references section

- www.designforall.org/ of the Design for All Foundation
- http://dfaeurope.eu/ of Design for All Europe
- https://data.worldbank.org/ of the WB
- https://data.worldbank.org/indicator of the WB
- https://shop.un.org/ of the UN publications
- www.undp.org/content/undp/en/home/ of the UNDP
- www.who.int/publications/en/ of the WHO
- www.who.int/gho/en/ of the WHO
- www.statista.com/

Others:

- British Standard (BS) 7000-6[1] – *Guide to Managing Inclusive Design*

This isn't a complete list but provides a starting point for finding out more. It offers us a straightforward route map for getting preliminary information that may help establish the literature of *design for equal accessibility* approach. It contains resources that aim to inform actors with the perspective of dynamic diversity.

[1] British Standard (BS) 7000-6 is a comprehensive guide to managing *inclusive design*. For more information, see footnotes p.164.

3.8.2. Actively involving diverse potential consumers in the design process:

As has previously been clarified, *problems of unequal accessibility* resulting from following the *dominant business model* are tangible realities. Such a model has resulted in solutions that are difficult to access by a wide range of people, especially the *poor*. The involvement of the *diverse potential consumers in the professionally guided design process as active actors* may contribute to avoiding such problems. In this process, the emphasis shifts to a more substantive and equal interaction between the *designer* and the *consumer*.

Initially, the *active participation of diverse potential consumers in the design process* can deeply illustrate the *variety regarding the empowerment* of people and their access environments. It helps realistically know about the contextual diversity regarding the access relation or the diversity of the characteristics related to empowerment of potential consumers and their access environments, thus, to get the realistic requirements of the wider population to develop a designed thing for equal accessibility. Engaging with *diverse potential consumers* including *non-mainstream ones (under-consumers – poor*, *rural*, *peripheral*, or *uneducated)* helps provide a focus for the design team and ensures that they may consider needs beyond their own immediate experience based on following the *dominant business system of production for the market* intentionally or unintentionally serving specific individuals, groups or societies.

In addition, actively involving *under-consumers* in the design process may be very fruitful. Such people devise ingenious ways of overcoming the difficulties they experience routinely with the designed world – *regarding problems of access*. They are experts as they always look beyond product features to detect potential problems. They can 'embody design questions that force the designers to think laterally and from first principles and ensure radical problem solving' (Cassim, J.: 2007, Empowering designers and users, p. 103). Regarding access, since *under-consumers* – particularly the poor – 'are most affected by the failure of design, a negative viewpoint can be transformed into an active critical awareness of alternatives and possible solutions that has enabled them to become *collaborators in the design process rather than mere spectators or critics*' (ibid.: p. 105). By active interaction with such people and acknowledging how they 'tackled everyday tasks from a different lateral perspective, designers would be confronted with *out-of-the-box* thinking in its purest form' (ibid.: p. 92).[1]

The *active participation of diverse potential consumers* in the design process provides what design guidelines and standards can't provide; in turn, the requirements of the acquired information may differ. Actually, consumers present the real scenarios of access based on their full awareness of their real characteristics and their access environments characteristics related to empowerment. This process may require spending time with people in their own environment, rather than working on a project abstractly in another space, it's another important part of the *PD process* (Chick, A.: 2011, p. 46). 'If you find yourself designing emergency shelters for poor black people from the comfort of a Soho design studio, you are not up to speed on an important change: *sustainable design* means the *co-design* of daily life with the people who are living it' (Thackara, J.: 2007, p. xvii).

This approach may be very fruitful and give completely new insights into the design process (Persson, H.: 2014, p. 510), thus contributing to helping designers consolidate conflicting data, eliminate impractical solutions, and focus on design directions that make sense in inclusive terms (Cassim, J.: 2007, Empowering designers and users, p. 103). Also, it can be a major force towards raising awareness and changing attitudes of the design community regarding equity and inclusivity (regarding equal accessibility). It's an inspiring process and helps demystify, illuminate and importantly empathize. In addition, consumers may suggest ideas and solutions which are valuable. The stimulus resulting from consumers' participation process may change the designers' learning curve and lead to creative thinking.

The rationale of involving *diverse potential consumers in the design process* is that this ensures that the final design outcome meets actual needs and requirements and is accessible by its intended audience (Chick, A.: 2011, p. 46). In turn, this enhances and enables the lives of people of all empowerment/access abilities, and actively captures new or overlooked markets even for designed things where the saturation point would appear to have been reached long ago (Cassim, J.: 2007, Empowering designers and users, p. 89).

[1] In this paragraph, the quoted parts are derived from a different context regarding involving non-mainstream potential end-users (mixed groups of users with severe sensory, mobility or dexterity disabilities to ensure that the major ergonomic issues are covered).

People 'are the real experts on themselves and their situation, so are encouraged to take a leading role in exploring potential solutions and opportunities' (Chick, A.: 2011, p. 48). They simply know the problem best and are the experts in relation to that problem, the expertise may be found in those whose interests are affected by the problem and its proposed solution (ibid.: p. 46, 47). Problem definition is itself subjective as it originates from a point of view; therefore all stakeholders' points of view are equally knowledgeable whether they are experts, designers or other actors (Fuad-Luke, A.: 2009, p. 142).

By working together it's possible to identify the points most in need of attention in the early design that aren't compatible with the needs of a particular group and resolve the problem without creating new problems for others. Without shared visions only short-term solutions are possible and these are unlikely to be the most sustainable solutions; shared visions, reached through *collaborative processes* are most likely to deliver sustainable solutions of long-term value (Chick, A.: 2011, p. 47). So, people have to dialogue, agree on how to frame the problem and agree on goals and actions; then participation in design seems essential (Fuad-Luke, A.: 2009, p. 142).

This approach may completely contribute to higher accessibility, and ensure it for consumers' categories represented in the participation process. This requires ensuring that chosen participating consumers are truly representative of the target consumer population. Following the *dominant business system 'production for the market'* in choosing the consumers actively involved in the design process will consequently lead to increasing the under-consumers.

More required directed efforts: While Nigel Whiteley noted over 2 decades ago 'that participation in design decision-making in consumer culture is token and effectively reduced to participation by affirmative purchasing only, there is evidence that the way the *consumer/ user* is now being involved in the design process is subtly changing' (ibid.: p. 147). There are some well-developed design approaches such as *PD*, *cooperative design* and *meta-design* that place particular emphasis on the participation of diverse stakeholders and actors – on involving people actively in a *co-design* process (ibid.).

Designing with *real users and consumers as stakeholders* has been typically accepted as an essential approach to developing designed things that fulfill the needs and requirements of the *wider* population (Cardoso, C.: 2007, p. 197). Nowadays, several activities, websites, books, conferences and journals are fully dedicated in a whole or a part to participation approaches. But unfortunately, most of such efforts have been directed to the *people's diverse characteristics related to use* including *non-mainstream* ones (e.g. elderly, impaired, novice) at the expense of the *people's diverse characteristics related to access* including *non-mainstream ones* (e.g. poor, rural, peripheral, uneducated); i.e. the most efforts have been directed to serve *equal use* at the expense of *equal empowerment* or *access*.

A clear example is the website *designingwithpeople.org* launched for a long period of time by the Helen Hamlyn Centre for Design at the RCA. This website provided practical resources that support *designing with real people*; in its *people* section, the website presented *10 real individuals with differing degrees of functional loss across the spectrum of capability*[1] – see section 2.11.2.2 – fig 2.14. They were selected under 5 categories – vision, hearing, mobility, dexterity and cognition – to represent a spectrum of capability across the UK population. In the same section, for each category, case studies provided further evidence of how people's needs and aspirations related to vision, hearing, mobility, dexterity and cognition can directly inspire better, more *equally usable design*.

A case study: Francisco Perez Anampa School – An effective role of co-design

One of the design entities which adopted *co-design* in its work is Architecture for Humanity (AfH)[2]. One of its early projects depending on the active participation of the problem owners in the design process is the Francisco Perez Anampa School located in Peru – see p. 304, 305.

> *The school building …….. was heavily damaged by the 7.9 earthquake in 2007. ……. During the school construction the design team worked closely with the community in order to engage a participatory process in which students and teachers were involved in a series of workshops. Engaging the community was very effective in directing design of a welcoming school using local construction procedures, materials and stamping some local flavor in the building. Also, participation was the key to highlighting the importance of having an environmentally friendly school in*

[1] yankilee.com/wwwdesigningwithpeopleorg

[2] AfH was a non-profit design services firm – a US-based charitable organization – that sought architectural solutions to humanitarian crises and brought professional design services to communities in need for building a more sustainable future through the power of professional design. Founded in 1999, it laid off its staff and closed down at the beginning of January 2015. (Wikipedia: Architecture for Humanity)

> *which passive systems, recycling, and construction waste management were all practiced during the design and construction process.*[1]

The architects learned more from the participants (teachers, students, parents and community members) involved in workshops and design charrettes, and became more confident about the main necessities and best design solutions for the school.[2]

Constraints: Despite the *direct involvement of potential consumers* in the design process is a very useful and inspiring approach; it isn't always feasible in everyday design practice (Cardoso, C.: 2007, p. 197). Many problems frequently prevent many designers and companies from having access to real consumers – especially *non-mainstream ones* – during the design process of designed things they create (Cardoso, C.: 2012, abstract). Such problems vary from time, cost, and logistical and sometimes ethical approval constraints to recruitment, and importantly in the process area itself – in how to do it (Cardoso, C.: 2012, abstract and Cassim, J.: 2007, Towards inclusion, p. 232).[3] Thus, designers are forced to rely on their own experience or intuition or on data based on the *dominant business system 'production for the market'* to guide their assumptions about the consumers' and access environments characteristics related to empowerment. Both resources may have little relationship to the true context.

'Here there is a real need to develop either a nation-wide resource, or a network of local resources and expertise that designers and companies can tap into. There is an equivalent need in education at degree and post-graduate level, but also in schools.' (Cassim, J.: 2007, Towards inclusion, p. 232)

[1] architectureforhumanity.org/node/1998

[2] ibid.

[3] The above information in this paragraph is modified from other different contexts interested in constraints of involving the end-users in the design process.

3.8.3. Working outside the served elites:

There will be a continuing and important need to work outside the *served elites* (*over -consumers*), where the accessibility challenges are the greatest. Without continuous work in this area, there's unlikely to be a stream of innovations that will deliver the highest level of accessibility in the future. Considering the *equal accessibility* in the design process results in designed things that could have an *added value* for those already included/served – now and in the future when their contextual characteristics related to empowerment may change. Design improvements aiming at the inclusion of the *under-consumers* can offer real benefits to the *served elites*; in turn, outcomes of such improvements can achieve market advantages.

There's a good reason to believe that innovations in this area will deliver important accessibility gains in the future. Several designed things have been directed to serve the under -consumers and have been becoming mainstream things. For example, LifeStraw® – a personal mobile water filter designed for underserved people in peripheral and rural areas or having no access to clean potable water – is currently being marketed in developed countries and over-consumers' markets as a product for hiking, backpacking, camping, travel, sports, outdoor activities and emergency preparedness, but in more stylish versions – see p. 287: 290. Another example is RoughRider wheelchair – a wheelchair being affordable, locally manufactured and highly functional in rugged terrain; while it has been founded for the poor impaired people in rough conditions of different performance environments in undeveloped countries, it's currently being marketed in developed countries (U.S., Canada, Europe, Australia and New Zealand) as a backup when life calls for off-pavement adventures, but in more stylish versions – see p. 213, 214. Also, design improvements aiming at the poor can offer real benefits to the rich regarding price, such as providing single-serve packaging of a detergent. Actually, designing for the *underserved people* can result in things that work better for everyone or bring about advantages for all citizens.

3.8.4. Creating realistic scenarios considering diverse potential access contexts – Scenarios:

Here, scenarios are storylines that explore the *potential contexts of access*. Creating a suitable and representative set of scenarios considering mainstream and non-mainstream (but realistic) potential access contexts and considering the effect of time on them in the design brief, can illustrate the *dynamic variety of consumers and access environments* of a designed thing or the *dynamic variety of contexts characteristics related to empowerment.*

While scenarios built on the existing reality represent a horizontal expansion via including people excluded from easy access, scenarios built on the effect of time on contexts characteristics related to empowerment represent a vertical expansion via predicting the realistic future of contexts. So, every proposed scenario needs to show a real contextual awareness of the present and future. 'The fact that the future can never be viewed or fully predicted does not negate our responsibility to identify possibilities that beg precautionary action' (Fry, T.: 2009, p.147). The future is filled with the attainments and mistakes of the past and present, which enable or disable possibilities; and well reading the past and present events would be helpful.

Creating present and futuristic scenarios for the access context whereas they include mainstream and non-mainstream[1] potential consumers and access environments, helps provide a focus for the design team and ensure that they may consider needs beyond their own immediate experience based on following the *dominant business system 'production for the market'* intentionally or unintentionally serving specific individuals, groups or societies.

The goal of using *realistic accurate scenarios* is to make the design community able to contemplate large-scale relational complexity resulting from the dynamic variety of contexts characteristics related to empowerment. Thus, it's expected that *inclusiveness* could be attendant – equal accessibility could be ensured. Accurate scenarios could potentially help attract design practitioners' attention and *empathy* towards the under-consumers. It attracts attention to the total contextual factors related to the access relation, and helps learn about the different conditions and communicate the corresponding real-world issues to others. In turn, this can be a major force towards raising awareness and changing attitudes of the

[1] non-mainstream consumers such as poor, rural, peripheral, having low political power or low social status; and non-mainstream access environments include all out-focus environments hindering the ease of access.

design community regarding equity and inclusivity (regarding equal accessibility). This may change the designers' learning curve and lead to creative thinking.

Equally, poor or imprecise scenarios could lead to assuming that the real contexts have been considered and the people's needs have been understood, which might result in inadequate assessment decisions, thus, unequally accessible outcomes again. The fewer the underserved /under-consumers, the more successful the proposed scenarios are.

Although it's fiction, the scenario has to stay within the realm of credible fiction. It has to be written from well-researched sources and via a critical imagination and a skeptical view of sensational predictions to form a reference work. More than one voice can assist in establishing a critical and credible narrative. Thus, different kinds of expertise, cultural backgrounds or politics may significantly and productively change perspectives. (ibid.: p.148)

The scenario needs to be elaborated in more detail to attach itself to specific circumstances in which the narrative can be tested for its credibility (ibid.: p.149). The characteristics included in the scenario must be realistic and truly representative in the potential contexts. This involves a thorough inclusion of their characteristics related to the access relation, and ideally a direct mapping to the number of contexts with such characteristics across the wider expected contexts. So, a deep understanding of the access relation and its related different contextual factors is a critical element in creating realistic scenarios. Also, identifying *context demographics within the target populations* is important because it helps the design community create the required realistic scenarios.

For building scenarios for the current reality for equal accessibility, just try to imagine for example, people being poor, rural, peripheral, with low political power, and with low social status as a part of the targeted consumers; in addition, try to imagine the physical world, support, policies and external attitudes in negative features which hinder ease of access of the proposed designed thing. This may cover a good number of the dynamic and diverse characteristics of access contexts. Such scenarios widen the range of accessibility requirements in the design brief.

For building futuristic scenarios considering the effect of time and for equal accessibility, just try to imagine for example potential negative changes in the financial abilities level of individuals and populations (the personal factor of income and wealth) – remember the economic crisis of Greece in 2007-2008; relocation of individuals and populations (the personal factor of geographical location) – remember moving of millions of refugees around the world; and potential negative changes in features of climate[1] (the environmental factor of natural physical world) induced by global warming – remember cities at risk from rising sea levels and relocation of their population to new ones. According to these scenarios, such predictive potential changes in the context characteristics related to access widen the range of accessibility requirements in the design brief.

[1] The climate is an element of the environmental factor '*natural physical world*'. Climate change has effects on global geographic transformations – including land in some parts of the world starting to be abandoned due to both: inundation from rising sea levels and higher temperatures making agriculture impossible. Associated with these events is an increasing scarcity of food and fresh water in these regions. These circumstances combine to produce millions of refugees who inflame the already growing global problem of population redistribution prompted by climate change. (Fry, T.: 2009, p.149)

3.8.5. Eliminating the fears – Motivations:

With calls for change, fears and defensive assumptions come; it's a repeated phenomenon. Without removing the aimed actors' fears towards the required change, they may not step to change their attitudes even if the previously proposed keys succeed in changing their perceptions (raising their awareness). For the design and business community, some issues may be considered as attitudinal barriers to changeability and enthusiasm towards the *design for equal accessibility* approach.

Regarding the design community, fears or defensive assumptions may revolve around:

- *Design for equal accessibility* would add more requirements and include diverse guidelines arising from having to consider all contextual factors related to empowerment, in turn, may constrict and abort creativity; e.g. the idea that designing for the poor would direct to relying on methods, materials and technologies that limit the ideas, in turn, limit the chances of creativity.
- Outcomes would be often poor style, low-quality and short-lived. Stereotypical images about existing things designed for the poor contribute to this view, which has given rise to the idea that aesthetics, quality and long-term are low on their agenda.
- The absence or lack of suitable formats of the required huge information aimed at designers would cause confusion, which in turn may affect the whole design process.
- Within the highly pressing constraints and deadlines of commercial design projects, there's a widely-held perception that implementing many new requirements is difficult to achieve, especially where the project is complex, involves other actors who may not adopt the same agenda or where the client is resistant.
- Difficulty to find talented design practitioners excited by challenges that have a humanitarian dimension, to work for the under-consumers, because their convictions that the *intellectual excitement* is in the over-consumers' sector.

To argue these fears or defensive assumptions, the debate about the reduction of creativity could stress on the nature of design as a creative process, which flourishes with increasing requirements. The reality of creation is to overcome the challenge. Actually, creativity motivates design practitioners to be challengeable. Also, poor style, low-quality and short-lived outcomes shouldn't be seen as a source of fear, but a result of design failure to adopt the equity, which in turn maximizes the challenge via avoiding such solutions and bringing together the best of technology and a global resource base to address the dynamic diversity of contexts. The upcoming successful case studies can demonstrate how *equally accessible design* can foster innovation and improve design, and show how it can combine inclusivity with style.

Regarding difficulties of achievement under the highly pressing constraints and deadlines of commercial design projects, changing the attitudes of the business community would be effective in eliminating this fear. As for the lack of appropriate formats of the required huge information, according to the principle of supply and demand, the demand of these formats would be the motivation of creating them.

Regarding the lack of talented practitioners keen to work in the under-consumers' sector, ambition by many designers to work in this arena isn't lack, 'students enter design school with youthful optimism and often come out at the end of their course ready to change the world' (Chick, A.: 2011, p. 70).

Many designers, design companies, and design schools keen to work for the real human needs, work for not-for-profit organizations and institutions (NFPs)[1], at a reduced fee or for free, or with some dedicating a specific amount of time to such activities (Marshall, T.: 2008, Not-For-Profit, p. 273). It's also common for students to undertake educational projects serving the needs of NFP agencies' charitable programmes (ibid.). Many private design schools are operated as NFP enterprises, any money made by a design school that operates on a not-for-profit basis must be returned to the institution's core mission (ibid.).

---

[1] NFP describes organizations and institutions whose sole purpose is to generate income exclusively for social, cultural, and environmental advancement. Legally, there can be no financial profit motive, otherwise, NFPs will contravene the 'favoured tax' status they work under in most countries and in most instances corporations can only make donations to NFP organizations. (Marshall, T.: 2008, Not-For-Profit, p. 273)

A business or other organization whose primary goal is making money (a profit), as opposed to a non-profit organization which focuses on a goal such as helping the community and is concerned with money only as much as necessary to keep the organization operating. Most companies considered to be businesses are for -profit organizations; this includes anything from retail stores to restaurants to insurance companies to real estate companies.

Read more at: businessdictionary.com/definition/for-profit-organization.html#ixzz2VvKTsSUg

Regarding the business community, businesses adopt a set of assumptions that obscures the value in the under-consumers' sector. Considering that the poor form the majority of such a sector, businesses fears or defensive assumptions often revolve around:

- The poor aren't the target market for businesses because they can't profitably compete for that market with their current cost structures (Prahalad, C.: 2002, p. 4).
- The poor can't afford and have no use for designed things sold in developed markets (ibid.).
- Only developed markets appreciate and will pay for new technology, while the poor can use the previous generation of technology (ibid.).
- The bottom of the economic pyramid isn't important to the long-term viability of the business and it's more suitable for governments and non-profits (ibid.).
- Managers aren't excited by business challenges that have a humanitarian dimension, and it's hard to find talented managers who want to work at the bottom of the economic pyramid because intellectual excitement is in developed markets (ibid.).
- Businesses can't run profitable last-mile supply chains, especially in rural areas which don't fit their types of businesses.
- It requires time, effort and money to rethink the business model, reshape consumer offers, retrain staff, and build a new knowledge base to adopt the *design for equal accessibility* approach.

Overall, not seeing profit in the under-consumers' markets is the main reason for the previous assumptions of why current businesses don't invest in such markets. So, there's a need to make businesses see a direct connection between *equally accessible design* and *profitability* to be a priority, or to review their assumptions about the under-consumers' market. To argue the aforementioned fears, we could stress on the following:

- The reality of unequal accessibility among people and populations – see section 3.5 – would encourage adopting *design for equal accessibility* approach; it demonstrates a great and ready-to-catch opportunity to add countless numbers of excluded people to the targeted consumers of a designed thing as well as to increase satisfaction for those who had difficulty to access it. The excluded represent a huge untapped market for profitable growth via expanding the consumers' base. Just think about the poor's segment around the world forming an invisible opportunity. In fact, given its vast size, the poor's segment represents a multitrillion-dollar market. According to WB projections, the population at the bottom of the economic pyramid could swell to more than 6 billion people in 2040, because the bulk of the world's population growth occurs there (Prahalad, C.: 2002, p. 2). The perception that the bottom of the pyramid isn't a viable market also fails to take into account the growing importance of the informal economy among the poorest of the poor, which by some estimates accounts for 40 to 60% of all economic activity in developing countries (ibid.). According to Paul Polak, businesses can generate positive returns for investors by serving consumers in the base of the pyramid populations with average household income in the range of $1: $2 per day (Wikipedia: Paul Polak). By adding the other people whose contexts characteristics regarding empowerment negatively affect their accessibility level, the under-consumers' segment represents a huge unexplored territory or virgin market for profitable growth, especially with the growth of their awareness of many products and services and aspiration to share the benefit; additionally, the more hospitable investment climate in developing countries (Prahalad, C.: 2002, p. 5).

> *Contrary to popular assumptions, the poor can be a very profitable market – especially if MNCs change their business models. Specifically, Tier 4 [1] is not a market that allows for the traditional pursuit of high margins; instead, profits are driven by volume and capital efficiency. Margins are likely to be low (by current norms), but unit sales can be extremely high. Managers who focus on gross margins will miss the opportunity at the bottom of the pyramid; managers who innovate and focus on economic profit will be rewarded.* (Prahalad, C.: 2002, p. 5)

- Ignoring the new reality regarding changes in individuals' expectations and aspirations – especially with the increase of international and governmental legislations of discrimination – may put commercial success at risk. The quest for equal rights has grown among people whatever their categories; now, people aspire to active participation within the mainstream of society, and the marginalized groups – such as poor, rural and uneducated people, are becoming more assertive in their demands. Not paying attention to this reality makes these groups turn towards other entities that provide what meets their expectations and aspirations. Regarding income, 'the real source of market promise is not the wealthy few in the developing world, or even the emerging middle-income consumers: It is the billions of aspiring poor who are joining the market economy for the first time' (Prahalad, C.: 2002, p. 1).

[1] Tier 4 includes people whose annual income is less than $ 1500 (Prahalad, C.: 2002, p. 2).

- Considering the *equal accessibility* in the design process results in designed things that could have an *added value* for those already included/served – now and in the future when their contextual characteristics related to empowerment may change. Design improvements aiming at the inclusion of the *under-consumers* can offer real benefits to the *served elites*; in turn, outcomes of such improvements can achieve market advantages. There's a good reason to believe that innovations in this area will deliver important accessibility gains in the future. Some products have been directed to serve the under-consumers and have been becoming mainstream products. See section 3.8.3. Working outside the *served elites*.
- The under-consumers' market is fortunately wide open for technological innovation; and it's a testing ground for sustainable living (Prahalad, C.: 2002, p.12). Companies can be leaders in leapfrogging to designed things that don't repeat the environmental mistakes of developed countries over the last decades (ibid.: p.4), and it will be logical to move into this wide-open market rather than trying to force their technology prematurely into applications for the developed markets, where incumbents and institutions stand in their way (ibid.: p. 9). In fact, for many emerging disruptive technologies such as fuel cells, photovoltaics, thin-film microelectronics, satellite-based telecommunications, biotechnology, and nanotechnology proposed to replace unsustainable technologies in developed countries, the bottom of the pyramid may prove to be the most attractive early market (ibid.: p. 14). Countries that still don't have the modern infrastructure or designed things to meet basic human needs are an ideal testing ground for developing environmentally sustainable technologies and designed things for the entire world (ibid.: p. 1, 2). Many of the innovations for them can be adapted for use in the resource-and energy-intensive markets of the developed world (ibid.: p. 12). These innovations won't only positively influence the choices of people at the bottom of the pyramid, but may ultimately reshape the way over-consumers live (ibid.: p. 8). With several billion potential customers around the world, investments in such innovations should be well worth it (ibid.: p. 9).

Design for equal accessibility will become even more important as the previous realities persist, especially when it's acknowledged and adopted by competitors. The markets of under-consumers present a prodigious opportunity for the world's wealthiest companies to seek their fortunes and bring prosperity to the aspiring *under-consumers* – especially the *poor*; for companies with resources and persistence to compete at the bottom of the world economic pyramid, the prospective rewards include growth, profits, and incalculable contributions to humankind (ibid.: p. 1). Investment in such markets means lifting billions of people out of poverties and desperation, averting the social decay, political chaos, terrorism, and environmental meltdown that is certain to continue if the *empowerment* gap among people, populations or countries continues to widen (ibid.: p. 2). Actually, a huge opportunity lies in breaking the dominant code[1] – in linking people across the world in a seamless market organized around the concept of sustainable growth and development (ibid.: p. 14). The use of commercial development to bring people out of poverties and give them the chance for a better life is critical to the stability and health of the global economy and the continued success of companies (ibid.: p. 4).

> *R. Kaku, the chairman of Canon summed it well when he said that the only entity whose effort to create stability matched its self interest was a corporation acting globally. The logic behind this is that as the developing countries become more peaceful and prosperous they provide new markets for Canon's products and services. Addressing the wider conflicts in the world, investing in developing countries and transferring technology helps these countries become stronger economic entities. ………. Therefore it has become in the self interest of global corporations to seek the well being and wealth of nations.* (Spahn, J.: 2003, p. 3)

Actually, the billions of people forming the under-consumers' market is a great opportunity for businesses. It also represents a chance for business, government, and civil society to join together in a common cause. Indeed, it can be believed that exploiting this opportunity by businesses dissolves the conflict among proponents of free trade and global capitalism on one hand, and environmental and social sustainability on the other. (Prahalad, C.: 2002, p. 14)

Successful implementation of *design for equal accessibility* can result in designed things that are equally accessible and ultimately profitable. Design decisions based on suitable insight into reality are likely to carry less risk (reduce the risk of undesirable and costly problems in the development lifecycle of designed things); and ultimately lead to clear differentiation from competitors (build competitive advantage), customer satisfaction and loyalty (encourage repeated purchases), and market success (Coleman, R.: 2007, Intro., p. 1-28).

The next case studies can explain how *equally accessible design* can be effectively put into practice. They provide compelling examples of design and business success – some of them are launched via successful, profitable chains. They help eliminate the fears of the design and business communities regarding the *design for equal accessibility* approach.

[1] It's the system in which the corporate sector serves the over-consumers while governments and NGOs undertake the protection of the under-consumers and the environment.

3.8.5.1. Successful case studies:

The following case studies are chosen to prove that the *equally accessible design* approach can foster innovation, improve design and create considerable commercial value in some cases – achieve market advantage, especially when managed effectively. They provide solutions for including the underserved people and populations via approaching one or both of the 2 main proposed paths: *context-fit* and *context-improve*. They are selected to cover a set of different satisfiers (water, shelter, health, education and job opportunities) required to equally meet some fundamental human needs.

1. Q Drum (water transporter)[1]: easy to transport water for the underserved people

Millions around the world, especially in rural Africa, live kilometers from a reliable source of clean water, leaving them vulnerable to cholera, dysentery, and other water-borne diseases. Water in adequate quantities is too heavy to carry. The Q Drum is a durable container designed to roll easily, and can transport 50 liters of clean and potable water. Rolling the water in a cylindrical container, rather than lifting and carrying it eases the burden of bringing water to those who need it. See fig. 3.2.

The Q Drum is a durable, donut-shaped plastic container which when full holds 50 litres of water. Its uniqueness lies in the design of the longitudinal shaft or central hole, through which a rope is tied, to pull or roll the drum along all terrain types. Due to the linear low-density polyethylene (LLDPE) it is made from, the drum is also practically indestructible and has no removable handles or other metal attachments that could detract from the Q Drum's intended purpose if lost or broken. The rope can be repaired on the spot or easily, if lost, be replaced by a leather thong, woven plant substance or any other appropriate material. The simplicity of the design ensures the ease of use.

- **Designer:** Piet Hendrikse – South African engineer, South Africa, 1993
- **Manufacturer:** Kaymac Rotomoulders and Pioneer Plastics
- **Capacity:** 50 Litres
- **Actual Weight:** 4,5 Kg
- **Filled Weight:** 54,5 Kg
- **In use:** Kenya, Namibia, Ethiopia, Rwanda, Cote d’Ivoire, Nigeria, South Africa, Ghana, Tanzania, Angola

[1] qdrum.co.za & qdrum.co.za/about-q-drum and designother90.org/solution/q-drum/

The Problem: 'The burden of fetching water, invariably over long distances by cumbersome and far too often, unhygienic means, is all too evident in developing countries.' (qdrum.co.za)

The Solution: 'The Q Drum is user friendly and the unique longitudinal shaft permits the drum to be pulled using a rope tied through the hole. There are no removable or breakable handles or axles, and the rope can be repaired on the spot or easily replaced.' (qdrum.co.za)





Fig. 3.2: Q Drum by South African engineer Piet Hendrikse (qdrum.co.za)

2. LifeStraw®: affordable safe drinking water for the underserved people

For ecological, economical, geographical and/or political reasons, 15% (1.1 billion) of the world`s population has no access to clean potable water – is deprived of household safe piped water, and 40% (2.6 billion) lack basic sanitation (UNDP: 2006, p. 2). Many peripheral or de-centralized small units don't ensure a better supply of freshwater – 'access to piped water into the household averages about 85% for the wealthiest 20% of the population, compared with 25% for the poorest 20%' (ibid.: p. 7). Lack of access to safe drinking water contributes to the staggering burden of diarrhoeal diseases worldwide (UNICEF and WHO: 2009, p. v), particularly affecting the young, the immuno-compromised and the poor. 'Nearly one in five child deaths – about 1.5 million each year – is due to diarrhoea. It kills more young children than AIDS, malaria and measles combined' (ibid.: p. 1). Drinking contaminated water also leads to reduced personal productive time, with widespread economic effects.

Thus, there's a pressing need for effective and affordable options for obtaining safe drinking water at home. *Point-of-use* treatment is an alternative approach, which can accelerate the health gains associated with the provision of safe drinking water to at-risk populations. It empowers people to control the quality of their drinking water.[1]

Treating water at the household level or other point of use also reduces the risk of water -borne disease arising from recontamination during collection, transport, and use in the home, a well-known cause of water-quality degradation (Wright, J.: 2004). 'Treating water in the home offers the opportunity for significant health gains at potentially dramatic cost savings over conventional improvements in water supplies' (IFC: p. 6), such as piped water connections to households.

Water filters have been shown to be the most effective intervention among all *point-of-use* water treatment methods for reducing diarrhoeal diseases. The Cochrane review demonstrates that it isn't enough to treat water at the *point-of-source*; it must also be made safe at the *point-of-consumption*. (Clasen, T.: 2009)

LifeStraw®, a personal mobile water-purification tool launched by Vestergaard Frandsen[2], is designed to turn any surface water into drinking water – fig. 3.3. It has proven to be effective against waterborne diseases such as typhoid, cholera, dysentery and diarrhea; it removes

[1] vestergaard-frandsen.com/lifestraw

[2] Vestergaard Frandsen is a company (a social enterprise) built on the foundation of humanitarian entrepreneurship and making products for humanitarian aid.

particles as small as fifteen microns. LifeStraw is a portable water filter for the prevention of common diarrhoeal disease; it can be carried around for easy access to safe and clean drinking water away from home, filters at least 1000L of contaminated water, removes minimum 99.9999% of waterborne bacteria, removes minimum 99.9% of waterborne protozoan parasites and reduces turbidity by filtering particles of approx. 0.2 microns. It contains no chemicals; has a high flow rate; and requires no electrical power, batteries or replacement parts. Now, it's used in Ghana, Nigeria, Pakistan and Uganda.[1]

Later, LifeStraw® Family has launched – fig. 3.4. It's a *point-of-use* instant microbiological water purifier. It's a *point-of-use* microbial water treatment system intended for routine use in low-income settings. It filters up to 18,000 litres of water, enough to supply a family of 5 with microbiologically clean drinking water for 3 years, thus removing the need for repeat intervention. It ensures a high flow rate and high volume of purified water; removes minimum 99.9999% of bacteria, minimum 99.99% of viruses, minimum 99.9% of protozoan cysts and turbidity; and requires no electrical power, batteries or replacement parts and no running water or piped-in water supply. It has an easy-to-clean pre-filter and purification cartridge. All its raw materials are US Food & Drug Administration compliant or equivalent.[2]

Also, LifeStraw® Community has launched – fig. 3.5. It's a high-volume *point-of-use* water purifier with built-in safe storage that provides safe drinking water for the community, educational and institutional settings. The chemical-free treatment prevents waterborne diseases such as diarrhea, typhoid, cholera, worms and cryptosporidiosis.[3]

The 3 models are *point-of-use* water interventions. They are truly unique offerings from Vestergaard Frandsen, which addresses the concern for affordably obtaining safe drinking water at home and outside. These complementary safe water tools have the potential to accelerate progress towards one of the Millennium Development Goals (MDGs) in regards to providing access to safe drinking water, which would yield health and economic benefits; so contributing to the achievement of other MDGs like poverty reduction, childhood survival, school attendance, gender equality and environment sustainability.[4]

[1] designother90.org/solution/lifestraw/ & vestergaard-frandsen.com/lifestraw and vestergaard-frandsen.com/lifestraw/lifestraw/features

[2] vestergaard-frandsen.com/lifestraw & vestergaard-frandsen.com/lifestraw/lifestraw-family and vestergaard-frandsen.com/lifestraw/lifestraw-family/features

[3] vestergaard-frandsen.com/lifestraw/lifestraw-community

[4] vestergaard-frandsen.com/lifestraw/lifestraw-family

Currently, LifeStraw® Go is being launched and marketed in developed countries and over -consumers' markets as a product for hiking, backpacking, camping, travel, sports, outdoor activities and emergency preparedness, but in more stylish versions – fig. 3.6.

Fig. 3.3: LifeStraw® by Vestergaard Frandsen (vestergaard-frandsen.com/lifestraw)

Fig. 3.4: LifeStraw® Family by Vestergaard Frandsen (vestergaard-frandsen.com/lifestraw/lifestraw-family)

Fig. 3.5: LifeStraw® Community by Vestergaard Frandsen (vestergaard-frandsen.com/lifestraw/lifestraw-community)

Fig. 3.6: LifeStraw® Go by Vestergaard Frandsen (lifestraw.com/products/lifestraw-go)

3. Ceramic Water Filter[1]: affordable safe drinking water – a local part

In Cambodia, nearly 66% of the rural population is without access to a safe water source. Unclean water poses a special threat to small children as a water-borne disease is a major contributor to Cambodia's under-five mortality rate of 83 per 1000 live births, one of the highest rates in Asia. Water-borne illnesses also result in lost labour productivity for households and missed school days for children.

To combat this problem, iDE – a non-profit organization – introduced and scaled up the manufacture of the Rabbit brand ceramic water filter – fig. 3.7, a low-cost household filter originally designed in Central America and popularized by Ron Rivera of Potters for Peace. The filter is produced locally using clay mixed with rice husk, which is formed into a pot shape using a press mold. The rice husk burns away during firing, leaving a porous filter element. A silver solution is then applied to the surfaces of the fired clay as a bactericide, after which it's set for use in a plastic receptacle tank with a lid and a spigot to prevent re-contamination of the water. The filter element holds approx. 10 litres (2.64 gallons), allowing a family to produce 30 litres (7.93 gallons) of water per day with 3 fillings, or more if required. Ceramic water filters can significantly improve household water quality (up to 99.99% reduction in E. coli) and can be manufactured locally and sold for under US$10.

Fig. 3.7: Ceramic Water Filter by iDE*

[1] ideorg.org/OurTechnologies/CeramicWaterFilter.aspx

* The photos on the right are from: ideorg.org/OurTechnologies/CeramicWaterFilter.aspx, and the photo on the left is from: pseau.org/outils/biblio/resume.php?d=2942.

In order to teach rural families about the benefits of owning a filter, iDE launched a nation-wide multichannel social marketing campaign for the filter, incl. broadcast radio and TV, bill-boards, school visits, and point-of-purchase displays. In June 2008, iDE celebrated the sale and distribution of 100,000 filters in Cambodia.

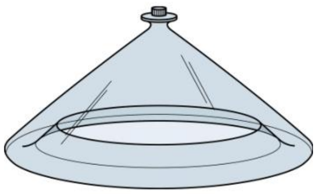
4. Watercone®[1]: clean potable water for the underserved people

The Watercone® is a mobile, lightweight (2 kg), easy-to-use and portable one-person solar still, which transforms saltwater (e.g. seawater) into purified drinking water alone by way of sunshine. The technology is simple in design and use. With up to 1.5 litres in 24 hours, the Watercone® is an ideal device to create a child's daily need for freshwater. The Watercone® system is a one-step water condensation process with a 40% effectiveness degree (GTZ Germany). Based on evaporation levels of 8.8 litres per square metre (average solar irradiation in Casablanca, Morocco), the Watercone® (with a base diameter of roughly 31.5", 80 cm) yields between 1 to 1.5 litres of condensed water per day (24 hours). The salty/brackish water evaporates by way of solar irradiation and the condensation from that water appears in the form of droplets on the inner wall of the cone. These droplets trickle down the inner wall into a circular trough at the inner base of the cone. See fig. 3.8.

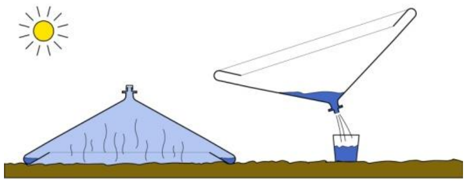
- **Designer:** Stephan Augustin (Germany) – the first Watercone was manufactured in Germany.
- **Manufacturer:** Stephan Augustin and MAGE WATER MANAGEMENT GMBH since 2008

Watercone in action

Watercone top with pan



Sketch of watercone top



Function sketch - simple, understandable and productive

Fig. 3.8: Watercone by Stephan Augustin – Germany (watercone.com/pictures.html)

[1] watercone.com/ & watercone.com/product.html and stinasolstrale.wordpress.com/2012/02/16/the-watercone-making-clean-drinking-water-avalible-to-everybody/

5. Eco-Beam and sandbag system[1]: low-cost housing

The Eco-Beam and sandbag system was developed in South Africa …… by engineer Mike Tremeer as a way of providing low-cost housing. Today, timber-frame and sandbag homes have found their way into many suburbs across South Africa, as this building process – and the specific design of the materials – is particularly cost-effective.

The building process, which can be undertaken easily without using highly skilled carpenters, is very simple and owner-builders can complete many of the stages that are involved themselves. The method consists of three elements: a framework of Eco-Beams (timber and metal beams that form the framework for the sandbag walls); specially formulated geo-fabric bags, filled with sand and stacked between the beams; and, finally, the cladding of the beams with wire mesh and either plaster, timber or plasterboard. The completed structure is waterproof (sand does not have the intrinsic capillary action found in cement), fireproof and soundproof, and has very good thermal properties. While standard walls may develop cracks in the plasterwork that can carry through the entire wall, this will not happen with this process, as cracks cannot run through sandbag walls. See fig. 3.9.

- ***Advantages:*** *Eco-Beam and sandbag homes can be produced and built in a short period of time, as no actual brickwork needs to be done. Once the beams and bags have been transported to the site, the framework can be erected within a few days. Design features such as curved walls or unusually shaped windows that would represent an increased cost in a brick structure would not be the case here. Once the framework is in place, filling and stacking sandbags can be undertaken by semi/ unskilled labour or by the owners themselves, reducing labour costs. Much of the sand required to build the structure can be obtained from the site.*
- ***Applications:*** *This form of construction is ideal in isolated areas, as the weight and design of the construction material make it easy to transport. Sites with lots of sandy soil are ideal.*

[1] earthbagbuilding.com/articles/eco-beam.htm

6. 10 X 10 Sandbag House[1]: Affordable housing rather than informal settlements

In Freedom Park, an informal settlement in the Mitchell's Plain township in Cape Town, corrugated-metal and scrap-material dwellings are being replaced by low-cost, two-story homes built with timber frames and sandbag in-fill construction. The 10×10 Sandbag Houses are architect Luyanda Mpahlwa's response to the 10×10 housing project initiated by Design Indaba, South Africa's renowned design-advocacy organization, which called for innovative housing solutions costing 50,000 rand (US$7,000) – the national government's housing subsidy – to build. Concurrently, the Freedom Park upgrading project mobilized community members, local organizations, and the provincial government to participate in creating dignified housing.

The design of the 10×10 Sandbag House borrows from indigenous mud-and-wattle building methods. A structural timber frame using EcoBeam technology (timber beams with metal inlays that provide tensile strength) is combined with sandbags reinforced with chicken wire and finished with plaster and timber cladding. The sandbags provide thermal insulation and, thanks to the EcoBeam technology, contributes to a system that is both wind-resistant (it is heavier than brick construction) and moisture-resistant. Moreover, the building method is cost-effective and energy-efficient, and requires little to no electricity and only minimal transport, since the EcoBeams are manufactured onsite. Little skilled labor is needed for construction, and local community members were involved in building the houses, demonstrating the possibility for replication in other communities. Given the small plot sizes allotted by the government for Freedom Park, the ability to build up rather than out ensures a solution that can accommodate density. Ten houses were completed in Freedom Park in 2009, and the building method can be scaled to help meet the urgent need for housing. See fig. 3.10.

[1] designother90.org/solution/10x10-sandbag-house/

Fig. 3.9: The Eco-Beam and sandbag system by engineer Mike Tremeer (earthbagbuilding.com/articles/eco-beam.htm)

Fig. 3.10: The 10×10 Sandbag Houses by architect Luyanda Mpahlwa & others (designother90.org/solution/10x10-sandbag-house/)

7. Plastic Formwork System: low-cost housing in developing countries – fig. 3.11

Every year, nearly seventy million people, or 200,000 a day, move from rural areas to urban cities. In South Africa alone, more than 2.2 million homes are currently needed, and an additional 180,000 homes will be needed every year to keep pace with rapid urbanization. The Plastic Formwork System is a method of building cast-in-place reinforced concrete structures, in which the walls of a house can be built in as little as a day by unskilled laborers with locally sourced materials and little waste. The system is comprised of square plastic components that join together to form wall panels from which the house is assembled. The house's infrastructure – steel-reinforcement bars, conduits, window and door frames, pipes and other fittings – is positioned on the wall; once in place, these elements are sandwiched between a second layer of panels, forming a cavity into which a lightweight concrete mortar is poured. After the mortar dries overnight, the Plastic Formwork panels are removed and reassembled for use at the next housing site, minimizing waste and transportation needs.[1]

The plastic formwork kits can each be reused to cast fifty homes, after which the plastic is recycled into household consumer products such as toilet seats. The result is a house that can both withstand natural disasters and provide thermal insulation and moisture resistance. Moreover, it leads to local job creation without compromising quality or integrity. The Plastic Formwork System has been used in housing projects throughout South Africa, and the company has established branches in thirteen countries, including Namibia, Mozambique, and Mexico.[2]

The moladi construction system was found in South Africa in 1986 as a method of building cast in place reinforced monolithic structures. The moladi technology was developed as a means to alleviate many of the cumbersome and costly aspects associated with conventional construction method without compromising on the quality or integrity of the structure.[3]

moladi is rapidly growing and proving itself to be the forerunner in the development of housing within poverty stricken areas. Informal partnerships between non-profit organizations and government institutions has inadvertently established moladi as the leading solution to the massive backlog of low cost housing as well as in addressing the inferior standards employed by many other companies within the housing sector.[4]

[1] designother90.org/solution/plastic-formwork-system/

[2] ibid.

[3] moladi.net/index.htm

[4] moladi.net/distribution_export.htm

moladi has been designed and manufactured to address the six key challenges that determine the successful implementation of low cost housing projects in developing countries. These challenges would be the lack of sufficient funds, the shortage of skilled labourers, a lack of resources, work-flow control, time constrains and wastage. The unique moladi monolithic cast housing system has succeeded in producing durable structures of quality in the shortest possible time.[1]

Fig. 3.11: Plastic Formwork System (designother90.org/solution/plastic-formwork-system/)

[1] moladi.net/technology_advantages.htm

8. Brilliance[1]: a world-class affordable phototherapy device

Jaundice is a critical global health issue among newborns. Jaundice is the 1st reason why newborns are admitted to hospitals worldwide. About 3 in 5 children have some degree of jaundice. For approx. 12% of babies, the condition is severe and requires treatment. Without timely treatment, a baby with severe jaundice may sustain brain damage or die.

> *Every year, at least 12 million newborns worldwide need phototherapy treatment for severe jaundice. Jaundice is no longer considered an issue in the West, but a combination of factors in developing countries such as lack of medical care access, inadequate infrastructure, ineffective treatment, and education results in a relatively high level of preventable death and disability.*
>
> *More than 6 million newborns each year do not receive the treatment they need. Yet jaundice is easy to treat. If detected early enough, it simply requires shining blue light onto a baby's skin for 2-3 days.*

Current treatment devices are costly to purchase and maintain. In studies of medical facilities in India and Nigeria, D-Rev[2] and Stanford found that 95% of devices evaluated in low-income hospitals and clinics didn't meet American Academy of Pediatrics standards. Maintenance was a key limitation in the delivery of treatment: approx. 1 in 3 phototherapy devices had at least one bulb burned out or missing. Blue compact fluorescent bulbs, commonly used in phototherapy devices, cost $17 per bulb to replace and last approx. 4 months. With devices using an average of 6 bulbs, many hospitals have trouble sourcing these bulbs and can't afford to replace them as needed.

To drastically reduce permanent brain damage to babies from delayed jaundice diagnosis and treatment, D-Rev developed Brilliance as a world-class, affordable phototherapy device designed for low-resource hospitals in urban (especially public ones) and peri-urban areas – fig. 3.12. It meets the American Academy of Pediatrics guidelines for intensive treatment and retails at $400, vs $3,000 for comparable phototherapy devices in the market. Brilliance went on sale in November 2012 through D-Rev partner, Phoenix Medical Systems.

---

[1] (D-Rev: 2012, p. 7, 8 and d-rev.org/projects/brilliance/need.html)

[2] D-Rev is a non-profit product development company founded by Paul Polak in 2007.

Advantages:

- **World-Class Treatment:** Tests at Stanford School of Medicine show Brilliance to perform on par or better than state-of-the-art phototherapy devices.
- **Minimal Maintenance:** Brilliance LEDs last 16-25x longer than compact fluorescent tube lights commonly used in phototherapy devices in low-resource hospitals. With Brilliance, hospitals can save over $200 per year on costly bulb replacements.
- **Energy Efficient:** Brilliance consumes half the power of compact fluorescent tube lights. In case of a blackout, it can be run off a battery backup (size of a car battery) for up to 8 hours.
- **Adjustable & Easy to Use:** Brilliance is designed for versatility of use, as dictated by medical staff in over forty hospitals. It meets the UNICEF phototherapy specifications and can be used with hospital beds, bassinets and other treatment surfaces.

D-Rev is developing Comet as an ultra-affordable, high-performance, compact phototherapy device targeting rural clinics and micro-hospitals. Not every baby has access to a large public hospital. Most babies in the developing world are born at home and their parents bring them to the closest facility, a clinic. Comet addresses this market and its unique needs, by being lightweight enough to be delivered on foot to remote locations, and small enough to work in tight spaces.

Fig. 3.12: Brilliance by D-Rev (D-Rev: 2012, p. 8 and d-rev.org/projects/brilliance/need.html)

9. Remotion Knee: an affordable and high-performance knee joint[1]

Globally, over 30 million people need mobility devices such as prosthetics. In the developing world – particularly in war-torn regions of Asia and Africa – trauma, disease, and natural disasters result in hundreds of thousands of new amputees per year. In the developing world, there are approx. 10 million above-knee amputees who lack access to prosthetics that would allow them to regain the freedom of mobility and return to work. Modern prosthetics are prohibitively expensive, costing thousands of dollars depending on their level of sophistication, and the knee joint is the most complex and expensive component of the leg prosthesis system. 80% of the world's amputees can't afford modern prosthetics. Existing, low -cost knees present significant limitations to mobility. Affordable prosthetic leg systems typically use single-axis knee joints – similar to a door hinge. While walking, particularly on rough terrain, they are unstable and can buckle, leading to a sudden and dangerous loss of balance. Existing solutions are inadequate: low-cost, locally manufactured knees are often mechanically unstable and unreliable, while donated Western knees are cost-prohibitive to acquire and maintain, and often perform poorly in the more rugged environments found in resource -limited settings.

D-Rev has created the ReMotion Knee which is a radically affordable polycentric knee joint that provides comparable performance to high-cost devices at less than $80.

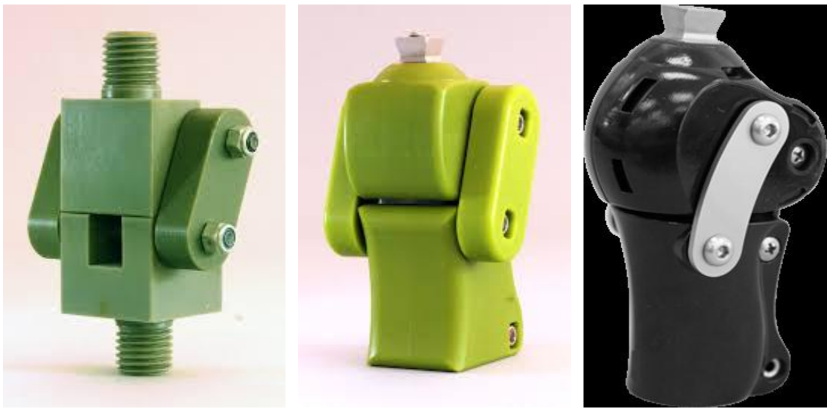
Advantages:

- **High Range of Motion:** 165-degree range enabling activities like kneeling, squatting and biking
- **Polycentric:** A higher degree of stability compared to single-axis devices, blending gait with a natural swinging motion
- **Water Resistant:** Withstands humid and wet climates without rusting or swelling
- **Durable:** Benchtop tested to 3: 5 years of use
- **Universal integration:** Pyramid adapter and tube clamp allow for integration with standard prosthetics systems
- **Lightweight:** Weighs only 0.68 kg
- **Noise Dampening:** Reduces noise during walking

[1] (D-Rev: 2012, p. 10, 11 and d-rev.org/projects/remotion/need.html)

By the end of 2012, 4,250 amputees fitted with the ReMotion Knee, and the design for the v3 ReMotion Knee, focusing on improved manufacturability, performance, and aesthetics was finalized for market launch in 2014. See fig. 3.13 and 3.14.

Fig. 3.13: Remotion Knee by D-Rev
(d-rev.org/projects/remotion/need.html and paulpolak.com/design)



V1 V2 V3

Fig. 3.14: 3 generations of Remotion Knee (D-Rev: 2012, p. 11)

10. Floating Community Lifeboats[1]: A low-cost and disaster-resistant solution

One-third of Bangladesh floods annually, with increasing frequency in recent years. In the flat, low-lying Ganges-Brahmaputra Delta, the most densely populated area in the world, six million people could lose their homes if water levels rose just half a meter (19 inches). Architect Mohammed Rezwan witnessed this firsthand growing up in the country's northern Natore region. During monsoon season, many children could not attend classes and often dropped out. Rather than

[1] designother90.org/solution/floating-community-lifeboats/ and shidhulai.org/

design buildings that would be underwater in his lifetime – Bangladesh is projected to lose 17% of its land by 2050 – Rezwan used $500 from a scholarship to found Shidhulai Swanirvar Sangstha – non-profit organization – in 1998 and designed the first floating school in 2002. Shidhulai currently operates fifty-four floating schools, libraries, health clinics, and a training center for parents, serving close to 90,000 families.

Working with area boat builders, Rezwan modifies traditional flat-bottom riverboats using local materials and building methods. Sitting low in water, they incorporate a metal truss to allow for column-free open spaces, flexible wooden floors, higher ceilings, and waterproof roofs outfitted with solar photovoltaic panels. Eighty percent of Bangladeshis lack regular access to electricity. The boats charge computers, lights, mobile phones, medical equipment, and SuryaHurricane lanterns – low-cost, portable solar-powered lamps made from recycled kerosene lanterns. Rezwan has also designed cluster housing outfitted with cooking facilities and toilets and a three-tier farming structure built on floating platforms. The floating farm's first tier is a planting bed made of water hyacinth and a bamboo truss for growing vegetables, beneath which fish are raised within net enclosures, while poultry can be raised on the top tier. See fig. 3.15.

Fig. 3.15: Floating Community Lifeboats by architect Mohammed Rezwan (designother90.org/solution/floating-community-lifeboats/)

11. Millennium School Bamboo project[1]: A low-cost and disaster-resistant school

The Philippine islands are hit with twenty to thirty typhoons every year, causing damage at a cost of up to 20 billion pesos (US$ 465 million) annually. In order to promote the change of investment priorities from post-disaster assistance to safer, more sustainable infrastructure solutions that could save lives and property, Illac Diaz of MyShelter Foundation[2] organized in 2008 the Millennium Schools Design Competition. Diaz called for the design of a school structure – often the place of refuge for poor residents during a typhoon – which could withstand 150-kph (93-mph) winds. Typical schools in this part of the world are hot, dark, and built with concrete, wood, and metal. The disaster-resistant design needed to be low-cost, use local and sustainable materials, minimize construction waste, incorporate natural light and ventilation, and be replicable in similar regions around the world.

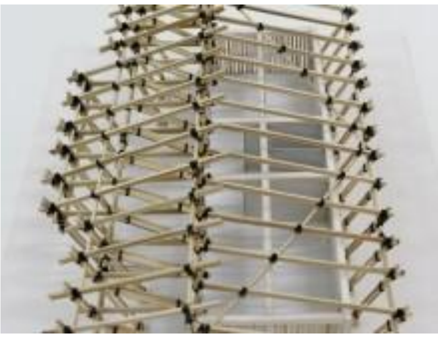




Fig. 3.16: Millennium School Bamboo designed by Eleena Jamil (designother90.org/solution/millennium-school-bamboo-project/)

The winning design, by Eleena Jamil of Malaysia, was built in 2010 on the Bicol Peninsula, an area heavily hit by typhoons. Inspired by vernacular houses found in the Philippines and Southeast Asia, the large, sloping roof and shaded veranda on one side provide shade for informal teaching or play. The simple design and arrangement of side-by-side classrooms allows for cross-ventilation,

[1] designother90.org/solution/millennium-school-bamboo-project/

[2] It's a social enterprise.

shade, and natural light. The bamboo and traditional woven-reed ceiling allows airflow and is easy to build and maintain. Lastly, a raised concrete platform keeps floors dry in the rainy season. The Millennium School is the first school in the Philippines to be constructed from bamboo – an inexpensive, strong, flexible, abundant, and sustainable material that can be harvested in three years (versus ten years for timber) – making Bamboo Project ideal for high-wind locations. See fig. 3.16.

12. Francisco Perez Anampa School[1]: an effective role of co-design

The Francisco Perez Anampa school is located in the community of Tate, a small town in the Ica Region 300 km south of Lima, Peru. ……… The school building attended by approximately 160 primary school students was heavily damaged by the 7.9 earthquake in 2007 that affected the Ica region in Peru. The entity assessing the quality of the buildings after the earthquake, Defensa Civil, confirmed that the building cannot be used anymore, as a safety precaution. The school had to be moved to a temporary location for more than 3 years, into improvised temporary school structures. Those times are remembered as very harsh as there was a lot of dust, limited water accessibility, no electricity, and the classrooms proved to be very cold in winter and extremely hot in summer.

Happy Hearts Fund and SURA School Rebuilding Program (Peru) decided to rebuild the school as the pro-activeness of the community and the big necessity to provide an effective educational environment was essential. The new facility will include six brand new classrooms, one library, a state-of-the-art computer lab, two administrative offices, a meeting room, an upgrade of the toilets, a courtyard, a snack kiosk, and a playing area for the children. See fig. 3.17.

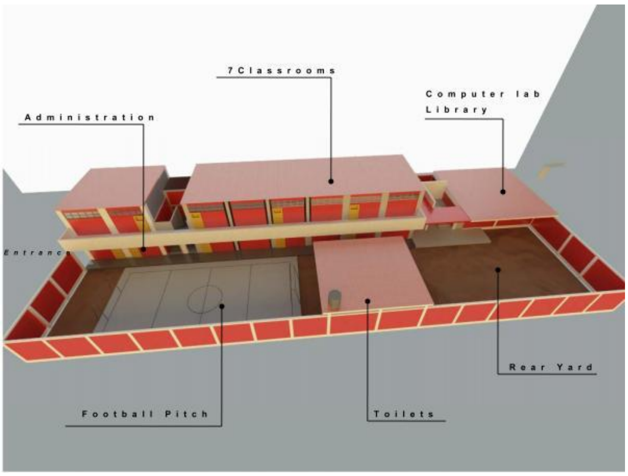
During the school construction, the design team worked closely with the community in order to engage in a participatory process in which students and teachers were involved in a series of workshops. Engaging the community was very effective in directing design of a welcoming school using local construction procedures, materials and stamping some local flavor in the building. Also, participation was the key to highlighting the importance of having an environmentally friendly school in which passive systems, recycling, and construction waste management were all practiced during the design and construction process.

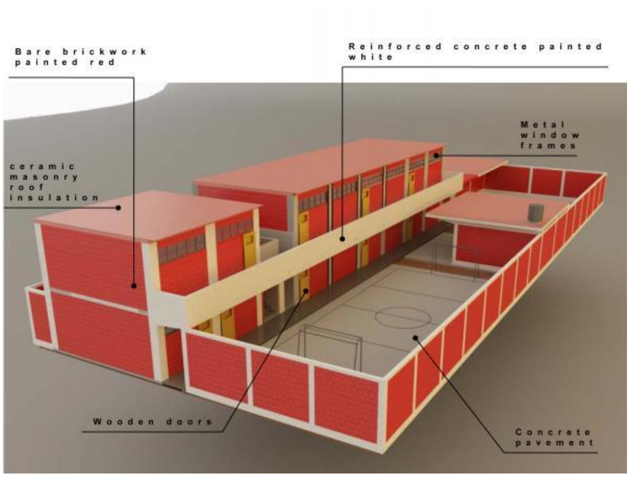
The effective charitable role of AfH was essential to review the existing project and provide design services to build more with less. The first step was to engage the community (teachers, students, parents and community members) via involving them in workshops and design

[1] architectureforhumanity.org/node/1998

charrettes in which the architects learned more from the users and became more confident about the main necessities and best design solutions for the school. Also during the construction stage, AfH was closely monitoring the construction site and providing construction administration services to build a quality infrastructure that will be used by the children of Tate in the next years.

The school is the project in which AfH took part by providing design services and construction administration through its highly collaborative design and construction process. Through the Happy Hearts Fund & SURA School Rebuilding Program, AfH designed and built a series of innovative schools for disaster-stricken communities of Central and South America (AfH: 2012, p 9).





School general planning and school materials: Project designed by Edificaciones America

Occupancy – School time

Fig. 3.17: Francisco Perez Anampa School (archdaily.com/351354/francisco-perez-anampa-school-architecture-for-humanity)

13. XO: a rugged, low-cost, low-power and connected laptop (educational tool)

Learning is the basis for full human, social, economic and democratic development[1]. Education means a chance for a better life. But for the majority of the children in the developing world, access to education and information remains difficult. Nicholas Negroponte[2] created the non-profit 'One Laptop per Child' foundation (OLPC) and worked with Yves Béhar/ fuseproject as OLPC's design partner to create a rugged, low-cost, low-power and connected laptop specifically adapted to school-aged children and their environment in developing countries for lowering the barriers that impede access to education, information, and communication (provide internet access) for the world's most needy children, in turn, to empower the world's poorest children through education. They provided strategic solutions to the making of the XO (also dubbed the $100 laptop), which led to the unique configure-ation and innovations that make the XO a true industry game-changer – fig. 3.18. The design intent was to make the XO immediately recognizable as a child's product, but not like a toy: the XO's look and feel are of a high-quality tool for education. Specific friendly design elements such as the soft edges, rubber keyboard, or turning the burdensome collaborative Wi-Fi antennas into whimsical rabbit ears, add a childlike feel to the laptop. They also designed the XO icon with its colour permutations that allow for 400 easily recognizable versions of the product and permeated both the product and user interface allowing personalization of each laptop for each child. XO is a uniquely low-cost and high-design product with particular attention to user needs and a challenging use environment – fig. 3.19.[3]

With access to this type of tool, children are engaged in their education, and learn, share, and create together; they become connected to the world and a brighter future[4]. Actually, OLPC is a technology story about how to provide low-cost educational tools to millions of children. OLPC is a great experiment in *SRD*, in which a non-profit organization harnesses cutting-edge personal technologies and distributes them on an unprecedented scale; governments purchase the laptops directly and distribute them to their schools[5].

[1] one.laptop.org/about/mission

[2] Nicholas Negroponte is an American computer scientist and professor at the Massachusetts Institute of Technology (MIT). He is a co-founder of the MIT Media Lab and the figurehead of the charitable initiative OLPC.

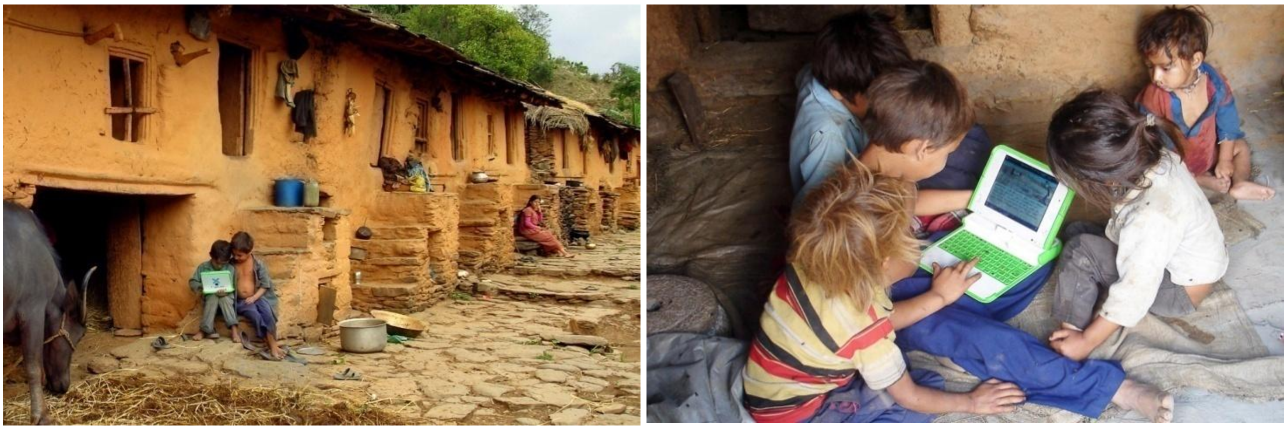
[3] fuseproject.com/category-1-product-3 and fuseproject.com/study-overview-3

[4] one.laptop.org/about/mission

[5] designnother90.org/solution/one-laptop-per-child/

By the end of 2012, Over 2 million children and teachers in 42 countries were learning with XO laptops[1]. These children receiving the original XO laptop had been the inspiration to create the next generations of this affordable educational tool.

Fig. 3.18: XO laptop by OLPC (one.laptop.org/stories)



Nepal: children down every path

Gaza and Ramallah: learning as a community   Madagascar: starting with the youngest

Fig. 3.19: XO laptop in action (one.laptop.org/stories)

[1] one.laptop.org/map

14. Optare Alero CSV: a service delivery vehicle for excluded rural communities (Cassim, J.: 2007, Designer education, p. 80, 81)

Despite a raft of social inclusion policies by local and national government, many of the UK's most deprived rural and urban communities remain geographically isolated in terms of transport and services. At least three-quarters of Britain's 17,000 small rural villages have no daily bus service, village shop or school age child care facilities, and many inner-city estates and districts are similarly deprived. Forty percent of the UK population now lives in the 88 most deprived local authority areas, against a backdrop of vanishing local economic outlets. Between 1995 and 2000, Britain lost 20% of its vital community institutions, such as corner shops, grocers, high street banks, post offices and pubs − 30,000 outlets in total.

Research associate: Owen Evans, RCA Vehicle Design (Vehicle Design at the RCA – the world's leading centre for vehicle design education and research)
Research partner: Optare (one of Britain's largest bus and coach makers)

The brief: To adapt the new accessible Optare Alero[1]*, a 16-seater low-floor vehicle*[2] *into an all -purpose service delivery vehicle to address the problems of rural and inner-city social exclusion and service provision.*

The methodology: An analysis of the Alero's capabilities in relation to leisure, corporate, health and local authority markets was carried out and compared with existing mobile services and future community needs. Gradually, a picture emerged of the need for a vehicle with display, desk and storage facilities within a reconfigurable interior that would be capable of providing the widest range of mobile services. Health education, youth outreach work, retail services, IT training, library and literacy services, citizens advice, and police and fire service liaison were among the services identified as community priorities. A series of interior layouts was tested and validated by a group of older and mobility-impaired people, using a full-size mock-up in the Vehicle Design Studio at the RCA. Key findings were then fed back into the design process to shape the develop-

[1] The Optare Alero was a low-floor integral minibus built by Optare between 2001 and 2008. It was built as an alternative to van-derived buses such as the Mercedes-Benz Sprinter. Around 300 were built in the first 5 years of production. The primary markets for the Alero have been community transport groups and rural demand -responsive bus routes, such as Hampshire's Cango. (en.goldenmap.com/Optare_Alero)

[2] A low-floor bus is a bus 'that has no steps between the ground and the floor of the bus at one or more entrances, and low floor for part or all of the passenger cabin. A bus with a partial low floor may also be referred to as a low-entry bus in some locations' (Wikipedia: Low-floor bus). Being low floor improves the accessibility of the bus for the public, particularly the elderly or infirm, or those with pushchairs, and increasingly, those in wheelchairs.

ment of the vehicle package and virtual modelling techniques were used to demonstrate the capabilities of the new Optare Alero CSV.

The results: The new vehicle called the Alero CSV (Community Service Vehicle) has a number of elements designed to give it maximum versatility. Roof-mounted awnings create the ability to 'host' events in a welcoming, open space in front of the vehicle. A dedicated trailer is included as an option to increase workspace or storage capacity, based on a standard Alero body shell. Roof -mounted air conditioning can be added for extended working periods in hot weather. Inside the vehicle, an electric generator has been packaged at the rear to provide power for onboard systems. Above this is a storage space that is accessible from the vehicle interior. Two removable tables provide workspace in the rear section, which can also serve as a private meeting room with the addition of a dividing wall. In the centre section, fixing rails provide the means to secure a number of movable elements – small and large desks, seating, storage units, bookshelves, entertainment and catering equipment. See fig. 3.20.

15. Virtual Office: a *paying-for-use* system

Virtual Office, founded in 1995, is a Brazilian company that offers its clients access to a virtual office. It offers complete office space, equipment, services and infrastructure helping its clients manage their business; the customers only pay for the time and services they require. The rooms of the Virtual Office are equipped with Wi-Fi, air conditioning, fine furnishings, and technical support and they can be rented for hours – fig. 3.21. Sharing equipment and office space allows them to be used more intensively and reduces the overall number of products necessary for individual users.[1]

Virtual Office with a reduced cost offers a prestigious address, and this empowers people with a low fiscal position to find a start point for their business or a suitable space to achieve some tasks.

Rather than individual ownership being always not affordable and sometimes risky, people with a low fiscal position and emerging businesses may turn to the *paying-for-use* system to reduce expenses and to be able to access a more 'in fashion' and more technological space for their private work.

[1] virtualoffice.com.br

The new vehicle Alero CSV (Community Service Vehicle)

The interior design of Alero CSV

Alero CSV provides workspace in the rear section and facilitates a number of leisure activities

Fig. 3.20: Optare Alero CSV – A Service Delivery Vehicle (furnace.squarespace.com/alero-csv/)

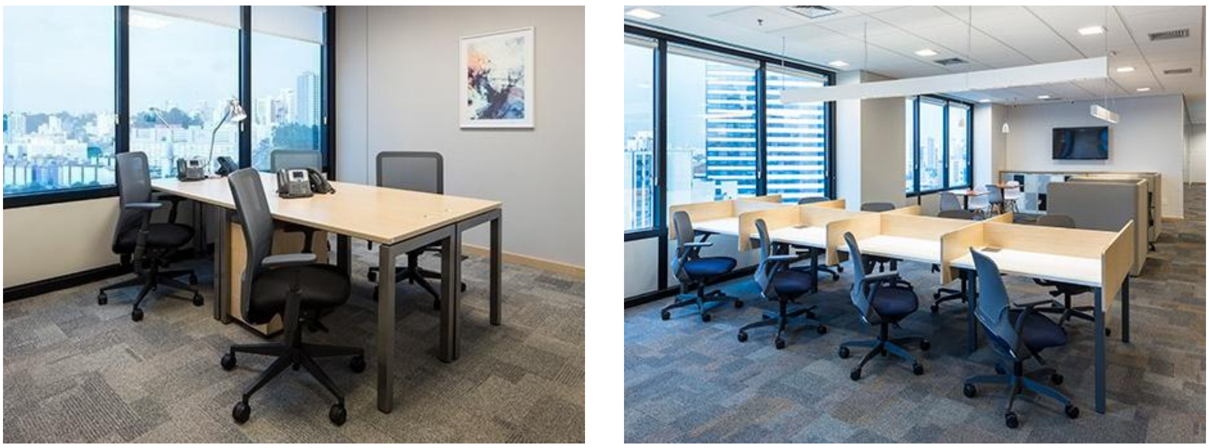


Fig. 3.21: Complete equipped office spaces via the *paying-for-use* system – Virtual Office (virtualoffice.com.br)

16. Wheel: an affordable detergent – a business success via low margins and high-volume sales (Prahalad, C.: 2002, p. 5, 6)

Hindustan Lever Ltd. (HLL), a subsidiary of Great Britain's Unilever PLC and widely considered the best-managed company in India, has been a pioneer among MNCs exploring markets at the bottom of the pyramid. For more than 50 years, HLL has served India's small elite who could afford to buy MNC products. In the 1990s, a local firm, Nirma Ltd., began offering detergent products for poor consumers, mostly in rural areas. In fact, Nirma created a new business system that included a new product formulation, low-cost manufacturing process, wide distribution network, special packaging for daily purchasing, and value pricing.

HLL, in typical MNC fashion, initially dismissed Nirma's strategy. However, as Nirma grew rapidly, HLL could see its local competitor was winning in a market it had disregarded. Ultimately, HLL saw its vulnerability and its opportunity. In 1995, the company responded with its own offering for this market, drastically altering its traditional business model.

HLL's new detergent, called Wheel, was formulated to substantially reduce the ratio of oil to water in the product, responding to the fact that the poor often wash their clothes in rivers and other public water systems. HLL decentralized the production, marketing, and distribution of the product to leverage the abundant labor pool in rural India, quickly creating sales channels through the thousands of small outlets where people at the bottom of the pyramid shop. HLL also changed the cost structure of its detergent business so it could introduce Wheel at a low price point.

Today, Nirma and HLL are close competitors in the detergent market, with 38 percent market share each, according to IndiaInfoline.com, a business intelligence and market research service. Unilever's own analysis of Nirma and HLL's competition in the detergent business reveals even more about the profit potential of the marketplace at the bottom of the pyramid.

Nirma has become one of the largest branded detergent makers in the world. Meanwhile, HLL, stimulated by its emergent rival and its changed business model, registered a 20 percent growth in revenues per year and a 25 percent growth in profits per year between 1995 and 2000. Over the same period, HLL's market capitalization grew to $12 billion – a growth rate of 40 percent per year. HLL's parent company, Unilever, also has benefited from its subsidiary's experience in India. Unilever transported HLL's business principles (not the product or the brand) to create a new detergent market among the poor in Brazil, where the Ala brand has been a big success. More important, Unilever has adopted the bottom of the pyramid as a corporate strategic priority.

17. Spring Health Water (India)**:** affordable safe drinking water and uplifting access abilities level of poor rural Indians

Most poor people lack access to clean water. Particularly in India, where around 30% of the population lives below the poverty line and simultaneously faces some of the worst drinking water conditions in the world. Is there a way to get water to them at a price point they can afford? That's the focus of Spring Health. Spring Health Water (India) Ltd., a for-profit enterprise, was founded in 2008 by the serial social entrepreneur and author of *Out of Poverty: What Works When Traditional Approaches Fail*, Paul Polak, and his social venture, Windhorse International, Inc. It's the 1st division of Windhorse International. Spring Health aims to supply safe, clean drinking water to underserved rural communities using a sustainable, *for -profit* model. The idea was to set up water tanks at the kiosks of rural entrepreneurs, fill them with local sources of water, treat the water with chlorine – a simple electrochlorination technology, and sell the water at a low price to villagers through such kiosks. Spring Health invests in the infrastructure to set up tanks at the kiosks of local entrepreneurs, with the entrepreneurs committing about 20% of the cost to ensure they have skin in the game. Customers would purchase the water from the kiosks directly, and revenues would be divided between the entrepreneur and Spring Health. See fig. 3.22.[1]

Later, Spring Health has implemented the water delivery service. The villagers could have clean water delivered to their doorstep, and kiosk owners would have the opportunity to expand the scale and scope of their businesses. Soon villagers from other social strata began requesting delivery service, more than willing to pay a few extra rupees for the convenience of delivery. Since its implementation, the delivery service has expanded the reach of its service and provided kiosk owners with an additional stream of revenue. See fig. 3.22.[2]

Purifying water at the point of sale through a proven radically affordable technique enables Spring Health to provide safe drinking water to rural households at very affordable rates; and this decentralized distribution system based on existing local kiosks, allows this model to reach small rural villages previously unviable to reach[3].

---

[1] social.yourstory.in/2013/01/spring-health-how-design-thinking-brought-clean-water-to-rural-india/ & paulpolak.com/the-future-corporation/ & youtube.com/watch?v=ezVxt7TkyeM&feature=youtu.be and paulpolak.com/spring-health/

[2] ibid

[3] idealist.org/view/business/Zcb3XxtPxWSP/

To date, Spring Health hasn't only proven the poor's ability to pay for clean water, but has found that the health benefits can actually save a family a significant amount of money over time, providing them with additional income to spend on feeding their children or sending them to school. And while Spring Health customers enjoy healthier lives and extra disposable income, the company itself is designed to generate enough revenue to attract external capital and scale-up. This simple business model not only ensured safe and affordable drinking water but also held the potential for financial returns – a requisite characteristic of any social enterprise that hopes to be sustainable and scalable.[1]

Fig. 3.22: Spring Health Water (India)*

[1] social.yourstory.in/2013/01/spring-health-how-design-thinking-brought-clean-water-to-rural-india/ & paulpolak.com/the-future-corporation/ & youtube.com/watch?v=ezVxt7TkyeM&feature=youtu.be and paulpolak.com/spring-health/

* ibid.

Spring Health is looking at bringing the discipline of *a market-driven for-profit enterprise in achieving the objectives that are social in nature, in a profitable and scalable model*.[1]

Actually, Spring Health has worked to combine radically affordable, life-saving or income -generating technology with radically decentralized supply chains to earn profits serving the underserved. It can run profitable last-mile supply chains in areas where it was difficult to do through normal design solutions – previously unviable to reach. The result, it seems, is that Spring Health may have found an answer to the original question, and through design thinking created solutions with the potential to *impact* the underserved people.

Conclusion:

- The aforementioned case studies in section 3.8.5.1 can explain how *equally accessible design* can be effectively put into practice. They provide solutions for including the *underserved* people and populations via approaching one or both of the 2 main proposed paths: *context -fit* and *context-improve*. These case studies serve as proof that *designing for equal accessibility* is a *realistic goal* and can be an achievable, worthwhile, and rewarding enterprise. They provide compelling examples of *design* and *business* success – some of them are launched via successful, *profitable* chains. They help eliminate the fears of the design and business communities regarding the *design for equal accessibility* approach and light up the way for them to do their neglected roles.
- These case studies demonstrate how the *design for equal accessibility* approach can foster innovation and improve design, and show how it can combine inclusivity with style. They prove that designing for the under-consumers doesn't limit the chances of creativity or does not necessarily lead to outcomes that are poor style, low-quality or short-lived; e.g. Brilliance phototherapy device, XO laptop, the 3rd generation of Remotion Knee, LifeStraw® water filter and Optare Alero CSV.
- Most of such case studies were launched via a *non-profitable chain*. This demonstrates the effective well-intentioned role of non-commercial entities – working as social enterprises – in initiating, adopting and supporting solutions for meeting the real human needs of the *under -consumers* (the underserved majority). The ceramic water filter was initiated and launched by iDE – a non-profit organization; the artificial Remotion Knee and Brilliance by D-Rev – a non-profit product development company; the XO laptop by OLPC – a non-profit foundation

[1] idealist.org/view/business/Zcb3XxtPxWSP/

by working with fuseproject as a design partner whose work includes supporting non-profit clients (civic works) in addition to its commercial projects; the 10×10 housing project was initiated by Design Indaba, South Africa's renowned design-advocacy organization and supported and adopted by community members, local organizations, and the provincial government; Floating Community Lifeboats were initiated and launched by Shidhulai Swanirvar Sangstha – a non-profit organization; Millennium School Bamboo project was initiated by MyShelter Foundation – a social enterprise; and Francisco Perez Anampa school was come to light by the effective role of the AfH – a non-profit design services firm (a charitable organization).

- Two of such case studies were launched via a *profitable chain* but via *achieving the objectives that are social in nature*. LifeStraw®, LifeStraw® Family and LifeStraw® Community were initiated and launched by Vestergaard Frandsen – a *profit-for-purpose* company (a *social* enterprise built on the foundation of humanitarian entrepreneurship); and affordable safe drinking water was offered by Spring Health Water (India) Ltd. – a *for-profit social* company. Another 2 case studies were launched via a *mainstream profitable chain* – Virtual Office and Wheel. The 4 case studies prove that the *equally accessible design* approach can create considerable commercial value – achieve a market advantage. Such case studies prove that there's a profit in the under-consumers' markets and a direct connection between *equally accessible design* and *profitability*. They prove that profits could be achieved not only by the common keys (manufacturing processes, developments in technology, product innovation and provision of ever-widening services (Coleman, R.: 2007, The Business Case, p.41) but also by adopting *inclusiveness* even if via *unusual models*. Regarding the example of Wheel detergent, it demonstrated that the poor can be a very profitable market, especially if companies change their business models. Specifically, the poor's markets aren't markets that allow for the traditional pursuit of high margins; instead, *profits are driven by volume and capital efficiency* (Prahalad, C.: 2002, p. 5). Margins are likely to be low, but unit sales can be extremely high (ibid.). Also, Wheel detergent and Spring Health Water have commercially succeeded via engineering *unusual market infrastructures*.

- These case studies demonstrate that for ensuring *inclusiveness* and *practicality* via *design for equal accessibility* approach, the *one-solution-fits-all* path isn't necessarily the only path, but it's the main path and there are other paths supporting it when it's insufficient – i.e. through a single solution when possible or diverse solutions when not. These case studies follow one or more path of the following paths:

- Reduce the level of ability required to access the designed thing as much as possible – reduce the designed thing demands – to achieve accessibility for an extended range of contexts; this expresses the *one-solution-fits-all* path; e.g. Brilliance phototherapy device, XO laptop, Remotion Knee and Virtual Office.
- Offer the designed thing in other modified versions; e.g. Wheel detergent.
- Offer the designed thing via different access systems, such as *ownership*, *common ownership*, and *paying-for-use*; e.g. Virtual Office as a *paying-for-use* system.
- Offer other *alternative solutions*; e.g. Q Drum water transporter, LifeStraw® water filter, Ceramic Water Filter, Watercone®, Plastic Formwork System, Eco-Beam and sandbag system, 10 X 10 Sandbag House, Floating Community Lifeboats, Millennium School Bamboo project, Optare Alero CSV, and Spring Health Water Ltd.
- As a last resort, *improve the context characteristics* (related to empowerment) of the underserved people through the designed thing chain; e.g. Wheel detergent and Spring Health Water Ltd.

Every case of the first 4 paths is a *context-fit* solution offered to match the empowerment -related characteristics of the underserved people's contexts. The cases of the 5th path are *context-improve* solutions offered to improve the context characteristics related to empowerment of the underserved for uplifting their access abilities.

- While case studies of the 1st path (*one-solution-fits-all* path) don't imply a separate, specialized or segregated solution, the case studies of the 2nd, 3rd and 4th paths show increasing levels of *customization*.
- The majority of such case studies point out that *localization* should be attendant *in some way* for equal accessibility. Some of them are created to fit specific contexts and similar (to *address or/and improve* local conditions, reality or capabilities regarding access – localizing the solution), they are cases *not* following the *one-solution-fits-all* path, such as Q Drum water transporter, LifeStraw® water filter, Ceramic Water Filter, Watercone®, Eco-Beam and sandbag system, 10 X 10 Sandbag House, Plastic Formwork System, Floating Community Lifeboats, Millennium School Bamboo project, Optare Alero CSV, Wheel detergent, and Spring Health Water Ltd.

Also, some case studies show another form of *localization* via considering small-scale local businesses and local culture; and/or relying on local people, businesses, technologies, crafts, designed things, resources and materials. For example, regarding Spring Health Water, the company formed alliances with the local entrepreneurs (owners of the existing local kiosks in small rural Indian villages) allowing it to provide affordable safe drinking water to reach such villages populations. Also, for Wheel detergent, HLL company decentralized the production, marketing and distribution of products to leverage the abundant labour pool in rural India, quickly creating sales channels through the thousands of small outlets where people at the bottom of the pyramid shop. Moreover, regarding Francisco Perez Anampa School, the design team of AfH worked closely with the community in a participatory process which was very effective in directing the design of a welcoming school using local construction procedures and materials, and stamping some local flavor in the school building. Additionally, regarding the Millennium School in the Philippines, the design – by Eleena Jamil, Malaysia – depended on local and sustainable materials – bamboo and reed, the bamboo is an inexpensive, strong, flexible, abundant, and sustainable material that can be harvested in 3 years (versus 10 years for timber).

- LifeStraw® water filter and Wheel detergent demonstrate that things designed for the under -consumers could have an *added value* for those already included/served *(elites)* – now and in the future when their contextual characteristics related to empowerment may change. For example, LifeStraw® – the personal mobile water filter designed for the underserved people in peripheral and rural areas or having no access to clean potable water – is currently marketed in developed countries and over-consumers' markets as a product for hiking, backpacking, camping, travel, sports, outdoor activities and emergency preparedness, but in more stylish versions. Actually, designing for the *underserved people* can result in things that work better for everyone or bring about advantages for all citizens.
- All case studies demonstrate the real value of design and how it could improve the lives of *under-consumers* around the world, and that it's possible to regain more of its lost social responsibility regarding *equity in meeting human needs* (*the 2nd area of SRD model*).
- The examples of Spring Health Water (India) Ltd., and Wheel detergent show how design has the power to be a part of the solution to global challenges like *unemployment* and *poverty* by following the *context-improve* path (improving the empowerment-related contextual characteristics of the underserved people through the targeted designed thing).

Regarding Spring Health Water, owners of local kiosks in small rural Indian villages have ensured an additional stream of revenue and local people have enjoyed healthier lives and extra disposable income. Also, for Wheel detergent, HLL Company decentralized the production, marketing and distribution of products to leverage the abundant labour pool in rural India, which has increased the earning potential of the poor by making them a party of the life cycle of the designed thing. Both examples have built a permanent solution to poverty and the poor can earn more and improve their families' position in the class pyramid and stay out of poverty. Thus, such income-generating things contribute to social and economic development.

In this, while design is playing one of its social roles regarding *equity in meeting human needs*, it plays an additional social role by embracing the new recently emerged area of *SRD* concerned with tackling the *wicked problems*. So, working on tackling such problems should not be classified as a separate SRD area but as a way of serving the following 2 areas of SRD model: *meeting human needs* and *equity in meeting human needs*. Such problems should be seen as inhibitors of features of the contextual factors that negatively affect contextual characteristics of people which should be considered for meeting their human needs.

- Most of these case studies and others formed the core of 2 noted exhibits of the Smithsonian's Cooper-Hewitt[1]: *Design for the Other 90%* (2007) and *Design with the Other 90%: cities* (2011).

3.8.6. Summary:

Briefly, section 3.8 has provided a journey among the fundamental keys proposed for raising awareness of all actors needed to promote the *equally accessible design message* within the design, business and decision-making communities. In this journey, the study has discussed all of the following keys: building up the relevant literature, actively involving diverse potential consumers in the design process, working outside the served elites, creating realistic scenarios considering diverse potential access contexts, and eliminating the fears. Also, the rationale for these keys**,** and the positive impact that such keys can have on the aimed actors and the final design outputs have been discussed. In addition, the journey has reviewed the positive signs regarding these keys; and some effective case studies to give certainty in the *design for equal accessibility* approach and eliminate the fears and doubts about it.

[1] – a national design museum in New York.

4. Discussion

4. Discussion

4.1. Navigation and conclusion:

It’s important to keep in mind that this study is concerned with the *social side of sustainability* at the expense of the *environmental* and *economic* side. It examines the phenomenon ‘*the correlation between design and the unsustainability state of the world*’ specifically ‘*social inequity in meeting human needs*’ via collectively evaluating the interaction effectiveness within *individual-designed thing relations of access, use and harmony* via which *equitability* could be achieved – fig. 1.1, or via evaluating how equitable accessibility, usability and harmonizability of designed things are across people. In this study, only equitability desired regarding accessibility and usability forms the basis of this study. For equitability desired regarding harmonizability is postponed for a later study – fig. 1.6.

To examine and tackle this phenomenon, answer the research questions and validate its hypotheses, the study has followed a *theoretical* and a *projective* path. Both are attendant in its 2 main parts titled ‘*design exclusion and usability*’ and ‘*design exclusion and accessibility*’.

4.1.1. The theoretical path:

With the end of the theoretical path of the 2 main parts of this study, it could be acknowledged that the answers to the 1st research question agree with its proposed hypotheses.

The 1st research question: What are the causes related to design practices that make design correlates with the *unsustainability state of the world* regarding the *social inequity in meeting human needs*? Or what don’t design practices consider and contribute to the *unsustainability state of the world* regarding *social inequity in meeting human needs*? For this question, the related research hypotheses have been:

- Not deeply considering the *dynamic diversity of people’s contexts characteristics* in design practices or *unequal design practices* is a main cause of the correlation between design and the *unsustainability state of the world* regarding the *social inequity in meeting human needs*.

- Past and current design practices serving under the dominant systems haven't considered the different levels of people's abilities of accessing and using designed things, which in turn has collectively created an unequal state in meeting human needs across people, has not collectively provided what empower what fully and consistently meet people's needs on an acceptable level, or has not collectively actualized the noble social role of design on an acceptable level.

Considering the aforementioned statistics and critical changes, and referring to the aforementioned expressive examples of *design exclusion* regarding *usability* or *accessibility* during the thesis, that can be invoked, it's clear that the human needs haven't been collectively satisfied on an acceptable level. Some basic needs of many people's segments haven't been included in the scope of design practice; many designed things can't be *equally usable* or *accessible* and simultaneously experienced by the largest number of people. What is so often evident is that the actors haven't deeply considered the *dynamic diversity of interaction contexts*, because if they had, then the people wouldn't have to experience such problems and frustrations. Actually, design as a means has lost more of its social responsibility regarding *equity in meeting human needs* (the 2nd area of SRD). This failure to deeply consider the *dynamic diversity of people's interaction contexts* in design practices sets *a correlation between the existing design state* and *the unsustainability state of the world* regarding *social inequity in meeting human needs*.

This justifies us to acknowledge that unequal design practices or not deeply considering the dynamic diversity of people's contexts characteristics in design practices is a verified cause behind the phenomenon 'the correlation between design and the unsustainability state of the world' specifically 'social inequity in meeting human needs'. Thus, we can acknowledge the validity of the 2 proposed research hypotheses answering the 1st research question.

This verified and generalized knowledge (*inductively* and *deductively*[1] inferred judgments) based on the accurate anatomy of the individual-designed thing relations of use and access, the deep clarification of the dynamic diversity of people's contexts, the accurate description of the socially unsustainable results of our current design paradigm (design exclusion), and

[1] For the theoretical path, *inductive* and *deductive reasoning* are the processes that have been followed to set descriptive/positivist statements – the verified and generalized *theoretical knowledge* (*about what is*).

the confirmation of the proposed cause related to design practices behind the phenomenon, has answered *what*, *how* and *why* this phenomenon. For this purpose, it has depended on the *qualitative analysis* method for analyzing and processing data; the collected data has been qualitatively analyzed and explained for extracting the scientific proofs, which answer the above research question and confirm its proposed hypotheses.

This verified and generalized *theoretical knowledge* addressing social considerations, identifying the weaknesses and failures of design in this context, and acknowledging concrete concepts and ideas, may be of value and achieve a more comprehensive and deeper understanding. Also, it may contribute to the growth of scientific knowledge and refine the *design theory*.

The theoretical path has helped acknowledge the next *conclusions* to confirm the previous hypotheses:

1. The individual-designed thing relations are immensely deep and include a vast array of interdisciplinary details:

The anatomy of individual-designed thing relations of use and access demonstrates how immensely deep the individual-designed thing interactions of use and access are, and how greatly wide the array of details of such relations are. Designing with all details in mind helps create a thing that may be well accessed and used in a specific context. Deep understanding and recognition of the full details of both relations are necessary because this forms the base through which we will be able to develop and evaluate:

- the quality of usability and accessibility of a designed thing in a specific interaction context at a specific moment,
- the quality of continuity with a satisfactory level of usability and accessibility of the same designed thing in the same interaction context under the effects of dynamism (changeability of the context characteristics with time),
- the quality of equitability regarding usability and accessibility of the same designed thing in diverse interaction contexts – under the effects of diversity of the potential interaction contexts characteristics.

Such details belong to the following points:

- Pillars and aspects of the use and access relations – see sections 2.2, 2.3, 2.4 and 3.2.
- The contextual factors types and their classifications according to the nature of relation – see sections 2.5, 2.6 and 3.3.
- The effects and their extent of the numerous contextual factors on one or more of the relation pillars, thus on the people's ability of using and accessing a designed thing, doing related tasks and participating in related life activities – see sections 2.5.1, 2.6.1 and 3.3.

The majority of such details belong to many different disciplines such as anatomy, physiology, neuroscience, psychology, sociology, etc., and they form *a unique interdisciplinary field*. Avoiding *design exclusion* requires *going deeply into* such disciplines through depending on *interdisciplinary* modes of working, studying, and knowing to reach the whole knowledge regarding the dynamic diversity of potential interaction contexts.

2. Diversity of interaction contexts is deeper than resonant statements:

'Diversity is the one true thing we all have in common.'

Author Unknown

'Diversity in the world is a basic characteristic of human society, and also the key condition for a lively and dynamic world as we see today.'

Hu Jintao[1]

Diversity is a tangible fact and statements about it are widely mentioned, but to what extent is it perceived? Diversity of interaction contexts isn't completely perceived by acknowledging only the types of contextual factors (personal and environmental factors), but by deeply recognizing their *different effects* and the extent of those effects on the pillars of use and access relations, thus on people's ability level of accessing and using designed things. Here, diversity isn't only about our different contexts characteristics, types of difference, or how we differ, *but rather about how our different contexts differently affect our interactions in life activities*.

[1] Hu Jintao (born 1942) is a Chinese politician, who was General Secretary of the Chinese Communist Party from 2002: 2012, and President of the People's Republic of China from 2003: 2013. (Wikipedia: Hu Jintao)

So, designing with all details related to the variety and plurality of the potential interaction contexts in mind helps create a thing that may be widely well accessed and used (equally accessible and used) in a specific moment.

3. Dynamism creates diversity on the individual level:

Dynamism (changeability with time) of the interaction contexts characteristics resulting from changes in features of the contextual factors is a tangible fact. It chronologically creates diverse forms of the same context. In turn, changes in such characteristics differently impact its human element's ability level of accessing and using designed things.

So, designing with all details related to the changeability of the interaction context characteristics in mind helps create a thing that may be well accessed and used for a long time in a specific context.

4. Design exclusion is a logical result:

Designed things empowering what meets human needs are already everywhere, but the problem lies in *unfairness*. While mainstream designed things may be created equal, the ability to access and use them isn't always equal across persons and populations. Unfortunately, in the dominant system – *production for the market* – most professional design practices serve via commerce and commercialism (Chick, A.: 2011, p. 70) whose primary purpose of *design for the market* is creating designed things for *profit*. Profit or the *self-interest* has become the main target of businesses at the expense of the *core purpose*[1] of businesses (the *common interest*); i.e. profit often gets translated into the core purpose of business, and such a model controlling design practices has become dominant.

'Exclusion by design is commonplace, both at home and in the workplace. It also represents the extreme reaction to poor design which leaves many frustrated or facing difficulty, even if not excluded' (Clarkson, J.: 2007, p. 178). Many individuals, groups and societies have been vulnerable to design exclusion regarding usability and accessibility, and consequently, their needs haven't been met. It's a logical result of the dominant design paradigm.

[1] The *core purpose* of a business is its most fundamental reason for being which contributes to the well-being of society either through meeting customer needs, developing people, promoting a cause or making the world a better place through its philosophy and action.

Regarding *design exclusion resulting from unequal usability*, in our current era of rapid economic expansion characterized by *design for mass production* – directing design curriculums, studies, postgraduate programmes, training, development and practices – people have been treated as *universal types* rather than individuals through depending on the *average user* model or *one-size-fits-all* approach. Also, usability tests are generally done in a *uniform* or *standard environment* where the features of environmental factors are under control and not completely identical to the ones of the actual performance environments. So, the *dominant paradigm of design* has been based on what could be known as the '*elusive context*'. Relying on the *average user* or *standard environment* is frequently misleading because it unintentionally excludes people. *Treating contexts as universal types ignores the diversity of contexts being already dynamic, and design exclusion is a logical result.* So, it wouldn't be strange when some targeted users find difficulty in using a designed thing or are unable to use it, although it's used for its predetermined purposes.

Additionally, under such a paradigm, people have been treated as 2 groups – able-bodied or impaired, male or female, older or young adult – and things are designed for one group at the expense of the other group. This enhances the chances of excluding a group of them via targeting intentionally or unintentionally specific segments without others.

Also, under such a blind paradigm directing design curriculums, studies, postgraduate programmes, training, development and practices, many points are unintentionally disregarded; such as the details of individual-designed thing relation of use, many of the contextual factors, and the effects and their extent of the numerous contextual factors on the people's ability of using a designed thing, doing related tasks and participating in related life activities. This hinders a designed thing from being well used, and more importantly, widely well used.

Regarding *design exclusion resulting from unequal accessibility*, the status quo of meeting human needs implies that the majority of the world's population still struggles to maintain a *quality of life* due to *access problems*, and thereby the potential for human development remains a considerable challenge (Fuad-Luke, A.: 2009, p.55). The basic human needs are only met for the global minority (ibid.: p. 56). *Empowerment-related contextual characteristics* such as low economic status, low social status, and meager or nonexistent available opportunities create *barriers to access*. The massive segment of the global population has remained largely invisible to the corporate sector (Prahalad, C.: 2002, p. 4). Tragically, capitalists have implicitly assumed that the higher-status segments of societies will be served by the corporate sector, while governments and NGOs will protect the others (ibid.: p. 14).

Thus, it may be concluded that the vast majority of the world population hasn't been traditionally serviced by professional designers. In many parts of the world, only the *higher -status* segments of societies have the opportunity to access designed things and benefit from them (Ashok, M.: 2009, p. 4-8). In this, those who access designed things are considered *elites*. It's clear that the *dynamic diversity of potential access contexts* (consumers and access environments) – in the same society or different societies – hasn't been taken into account or included in the scope of design practices or addressed through the design process. Actually, such practices are *insensitive* to the *realities of access contexts*.

Unfortunately, the situation hasn't changed in the *globalization* era. In a globalized world, there's mounting evidence that globalization doesn't have salutary effects on *equity* and *equality*, within or among nations. 'Free trade, foreign direct investment, cross-border financial flows, and rapid sharing of technological innovations have not created a 'flat' world except insofar as the world's managerial classes are concerned' (Appadurai, A.: 2008, p. 195). Thus, for the world's low-status segments, 'globalization is still substantially an unkept promise, and in some cases, a broken contract' (ibid.: p. 195,196). It leaves behind such segments (Ashok, M.: 2009, p. 4-8). While globalization has demonstrated benefits regarding the free flow of trade, finance, and people, it has widened the current gap *regarding empowerment* in many societies (ibid.). Actually and via the statistics mentioned in section 3.5.1 and expressing the reality in our globalized world, still only some segments in many parts of the world have the opportunity to access the mainstream designed things and benefit from them. It reveals that design practices within the era of globalization are continuing to intentionally or unintentionally serve specific segments around the world without the others, which in turn, widen the gap among segments of the targeted societies. Intentionally is via targeting specific segments in specific outside markets, and unintentionally is via shallow recognition of the *realities of people's access contexts regarding empowerment*.

Finally, design exclusion regarding usability and accessibility is a logical result according to all the above features of the dominant design paradigm. A more holistic understanding of the meaning of decisions and their impacts is lacking because design within this system is far from the real recognition of the people's interaction contexts.

Debate on *design exclusion* demonstrates that:

- Diversity and dynamism require diversity:

'Diversity is the magic. It is the first manifestation, the first beginning of the differentiation of a thing and of simple identity. The greater the diversity, the greater the perfection.'

Thomas Berry[1]

'Differences challenge assumptions.'

Anne Wilson Schaef[2]

'I can tell you, without diversity, creativity remains stagnant.'

Edward K. Enninful[3]

Such statements exactly agree with *Ashby's*[4] *Law of Requisite Variety*[5] (1958) which stated that 'the variety in the control system must be equal to or larger than the variety of the perturbations in order to maintain stability' (Ashby, W.: 1958). 'The larger the variety of actions available to a control system, the larger the variety of perturbations it is able to compensate' (Heylighen, F.: 2001). 'The Law has many forms, but it is very simple and commonsensical: a model system or controller can only model or control something to the extent that it has sufficient internal variety to represent it' (ibid.).

The dominant design paradigm is most fundamentally formulated as a reduction of variety. Inflexible design models lacking a variety of actions/solutions to fit the diversity and dyna-

[1] Thomas Berry (1914: 2009) was one of the 20th century's most prescient and profound thinkers. As a cultural historian, he sought a broader perspective on humanity's relationship to the Earth to respond to the ecological and social challenges of our times. (thomasberry.org)

[2] Anne Wilson Schaef (1934: 2020) was an internationally known American author, speaker, consultant, and seminar leader who has been described as one of the most important thinkers of our time, cutting edge, way ahead of her time, and having the vision of the eagle. (annewilsonschaef.com)

[3] Edward Kobina Enninful (born 1972) is the editor-in-chief of British Vogue. Ghanaian-born Enninful was appointed Editor in Chief of British Vogue in 2017, making him the only Black editor in history to head any of the 26 Vogue magazines, and where he has continued his career-long work to bring more inclusivity and representation to the industry. (Wikipedia: Edward Enninful)

[4] William Ross Ashby (1903: 1972) was an English psychiatrist and a pioneer in cybernetics, the study of the science of communications and automatic control systems in both machines and living things. He was widely influential within cybernetics, systems theory and more recently, complex systems. (Wikipedia: W. Ross Ashby)

[5] Ashby's law is perhaps the most famous (and some would say the only successful) principle of cybernetics recognized by the whole Cybernetics and Systems Science community. (Heylighen, F.: 2001)

mism of interaction contexts in the *system of meeting human needs* create troubles in such a system, especially with the fact that well-intentioned NGOs, communities, some local governments (loaded with problems), entrepreneurs, and even multilateral development agencies are unable to completely change the dire reality resulting from such troubles. Treating all contexts as the same leads to excluding many people from benefiting from the mainstream designed things, and consequently, their needs aren't met.

- Development goes in the wrong direction:

Without equity, development is useless.

Rihan H. R. Hussein

Considering the status quo of meeting human needs on the collective level – mentioned in the thesis, it's clear that the human needs haven't been satisfied collectively on an acceptable level, and there's no doubt that the *current path of development is misleading*. This path relies on economic indicators such as the GNP and GDP that consider economic gains and losses, or on the quantitative growth of designed things (viability of production-consumption systems) to express the quality of life and well-being. The best development path is that which allows the greatest improvement in people's quality of life, which relies on the possibilities (*satisfiers*, *designed things*) people have to adequately satisfy their fundamental human needs (Max-Neef, M.: 1991, p. 16). This requires an indicator for the qualitative growth of people, not of the quantitative growth of objects. This required indicator goes beyond the conventional economic rationale because it applies to the human being as a whole (ibid.: p. 23).

- Change is inevitable:

'Our ability to reach unity in diversity will be the beauty and the test of our civilization.'

Mahatma Gandhi[1]

'Society is unity in diversity.'

George Herbert Mead[2]

[1] Mohandas K. Gandhi (1869: 1948) was an Indian lawyer, anti-colonial nationalist and political ethicist, who employed nonviolent resistance to lead the successful campaign for India's independence from British rule, and in turn, inspired movements for civil rights and freedom across the world. (Wikipedia: Mahatma Gandhi)

[2] George Herbert Mead (1863: 1931) was an American philosopher, sociologist, and psychologist. He was one of several distinguished pragmatists. (Wikipedia: George Herbert Mead)

The greatest success isn't to create a need or a designed thing to satisfy a need but to equally fulfill it.

Rihan H. R. Hussein

Navigating through the theoretical parts of the 2 main parts of this thesis demonstrates that there's a pressing need to change. Considering the aforementioned realities, statistics, critical changes, and expressive examples of *design exclusion regarding usability and accessibility* in sections 2.8, 2.9.1 and 3.5 respectively, this demonstrates that *design exclusion exceeds the limits* and the human needs haven't been collectively satisfied on an acceptable level. Design as a means has lost more of its social responsibility regarding *equity in meeting human needs* (the 2nd area of SRD). Where the design considerations of *equal usability and accessibility* have been previously overlooked, it's now impossible for design practitioners to continue to ignore them, and imperative to avoid treating all contexts as the same. Therefore, we should acknowledge that *real success isn't complete until a need is equally fulfilled*. The continuation of design practices to serve specific individuals, groups or societies without the others widens the gap among people rather than narrows it, which in turn may result in cracks among members and segments of the same society and among societies. Increasing the level of inequity state in and among societies negatively affects human and sustainable development.

This increases the need to *make changes in design practices* so that design is sensitive to the *dynamic diversity of potential interaction contexts*; i.e. things must be designed to serve well in the potential diverse contexts. Actually, a *revolution in design and business* is needed to reach the excluded segments and to regain *social* relevance.

This offers the rationale for seeking to structure and establish *projective knowledge* based on the verified and generalized *theoretical knowledge* of the theoretical path to form together effective knowledge that may be of value in refining the *design theory*, which in turn helps guide the new design practices to produce *socially sustainable design*. Thus, the approaches '*design for equal usability*' and '*design for equal accessibility*' have been here established as main parts of the general approach '*equitable design*'. Such approaches and their details form the projective path of this study.

4.1.2. The projective path:

With the end of the projective path of the 2 main parts of this study, it could be acknowledged that the answer to the 2nd research question agrees with its proposed hypothesis:

The 2nd research question: How does the recognition of the causes behind the phenomenon '*the correlation between design and the unsustainability state of the world*' specifically '*social inequity in meeting human needs*' contribute to tackling this phenomenon? For this question, the research hypothesis has been:

- Validating the proposed hypotheses of the theoretical path and recognizing the definitive causes behind the phenomenon could facilitate structuring and establishing new *projective knowledge* that would be inherently more socially sustainable. This knowledge may be of value and applicably useful in solving urgent problems and helping avoid the phenomenon; and will hopefully raise the awareness needed to promote its message within the *design*, *business* and *decision-making communities* – i.e. to change the mindsets of all actors, which in turn may pave the way for shaping humans' future in a socially sustainable fashion.

Confirming that *unequal design practices* or *not deeply considering the dynamic diversity of people's contexts characteristics in design practices* is a main cause behind the phenomenon under study, has facilitated structuring and establishing the *design for equal usability* and *design for equal accessibility* approaches for supporting the *optimal model of sustainable design*. In both approaches, *equitability* is of *primary consideration* and adequately addressed. For each approach, diverse *paths* have been introduced to ensure that all people find what is useable and accessible for participating in daily life activities, achieving tasks and satisfying their human needs. Also, for each approach, some *fundamental keys* have been structured and established for raising awareness needed to promote its message within the *design, business and decision-making communities*, i.e. to change the mindsets/attitudes of all actors. This structured and established *projective knowledge* may be of value and applicably useful in helping avoid design exclusion, and tackle the pressing and complex problems of a world made socially unsustainable. Also, it may contribute to the growth of scientific knowledge and refine the *design theory*, which in turn guides the new design practices to address the *agenda of sustainability* regarding *social equity in meeting human needs – equity within generations* – and pave the way for shaping humans' future in a socially sustainable fashion.

This structured and established knowledge (*abductively*[1] inferred judgments) represented in *both approaches*, their supporting *paths*, and the *fundamental keys* structured and clarified for raising awareness toward them, has answered *what* should be done or changed and *how* in light of the facts and generalizations derived from the theoretical path. For this, it has depended on the *qualitative analysis* method for analyzing and processing data; the extracted data from the theoretical parts has been qualitatively analyzed and explained for setting up new *projective knowledge*.

The establishment of this *projective knowledge* justifies us to acknowledge that validating the proposed hypotheses of the theoretical path and recognizing the definitive causes behind the phenomenon under study have facilitated structuring and establishing new projective knowledge that is inherently more socially sustainable. *Thus, we can acknowledge the validity of the previously proposed research hypothesis answering the 2nd research question.*

The projective path has helped establish detailed knowledge. It is accumulated and supported by additional projective knowledge to form the following points:

4.1.2.1. Equitable Design:

Responding to the *verified and generalized theoretical knowledge*, and to consider practically the dynamic diversity of people's contexts characteristics in design practices – i.e. to take into account *inclusiveness* and *practicality* – for ensuring the adoption of *equity in meeting human needs* by the actors, the projective study has worked on establishing the *equitable design* approach mainly based on diverse solutions when the *one solution isn't practical.* This general approach includes the established 2 approaches '*design for equal usability*' and '*design for equal accessibility*', and the *design for equal harmonizability*[2] approach postponed for a prospective study – fig. 1.6.

---

[1] For the projective path, *abductive reasoning* is the process that has been followed to set prescriptive/normative statements – structured and established *projective knowledge* (*what ought to be*) – on the basis of descriptive/positivist statements – verified and generalized *theoretical knowledge* (*about what is*).

[2] *Design for equal harmonizability* can be defined as:

- ''the design of mainstream things to be harmonizable by as many people as possible even if through diverse solutions when inevitable.''
- ''the design that ensures harmonizability for the widest possible people even if through diverse solutions.''
- ''the design that ensures that all people find what is harmonizable for satisfying a specific human need regardless of their different contexts.''

Thus, *equally harmonizable design is design that considers the full range of personal and environmental dynamic diversity of potential interaction contexts with respect to the harmony relation whether through a single solution when possible or diverse solutions when not.*

1. Concept:

Equitable design can be defined as:

- ''the design of mainstream things to be usable, accessible and harmonizable by as many people as possible even if through diverse solutions when inevitable.''
- ''the design that ensures usability, accessibility and harmonizability for the widest possible people even if through diverse solutions.''
- ''the design that ensures that all people find what is useable, accessible and harmonizable for satisfying a specific human need regardless of their different contexts.''

Thus, *equitable design is design that considers the full range of personal and environmental dynamic diversity of potential interaction contexts whether through a single solution when possible or diverse solutions when not.*

2. Features of equitable design:

- **It's a context-sensitive approach:** For countering *design exclusion* regarding usability, accessibility and harmonizability and avoiding the need for *reactive actions*[1] necessary to protect the excluded majority, the *equitable design* approach is based on the principle of inclusion. It refers to design based on a *context-sensitive* approach that places the *dynamic diversity of interaction contexts* at the heart of the design process. The real contexts are much more complex and must be considered from wider perspectives. The related line of reasoning is that since both people and interaction environments are dynamic and diverse, thus, people have different requirements for usability, accessibility and harmonizability, and it's necessary to consider all of them in a *context-sensitive* design process. So, it's a more *holistic* approach seeking to consider a *wider range of requirements*. It challenges the *conventional design paradigm* adopting the *average case* model (the average user or the standard environment) or targeting specific people, groups or societies.

  To this end, the characteristics of the broadest potential contexts must be taken into account throughout the entire development life cycle of new designed things as early as possible (from the early design phases).

[1] (posterior adaptations or posterior specialized designs)

- **It's a process:** *Equitable design* approach is a *process*, not an outcome. It works on delivering a thoughtful design space populated with appropriate alternatives which ensures that all people find what is effectively usable, accessible and harmonizable for participating in a specific life activity or satisfying a specific human need regardless of the contextual factors (personal and environmental factors) – see successful case studies in sections 2.11.8.1 and 3.8.5.1. It aims that no one should be excluded because of his/her context characteristics. The best practices regarding *equitable design* will be those focusing on the *context-sensitive* and *process-oriented* nature of design.

  To reach a successful and cost-effective realization of this vision, it's critical to ensure that appropriate frameworks, methods, techniques and tools of a designed thing development are available to support design practitioners to *identify* the real requirements according to the *equitable design* concept in the initial phases of the design process and to *integrate* the consideration of dynamic diversity of interaction contexts throughout all phases of the design process. Traditional frameworks, methods, techniques and tools serving the dominant design paradigm targeted toward the *average case* or specific individuals, groups or societies, are clearly inappropriate for addressing the new demands for *equity*; they are suboptimal since they can't accommodate diversity and dynamism.

  Main efforts in this direction are concerned with the identification and study of various non -mainstream target groups (e.g. the disabled, elderly, novice users, poor, rural, peripheral, uneducated, etc.), as well as of their requirements for interaction; the identification and study of various potential interaction environments, as well as of their requirements for interaction; and the identification, design and development of appropriate frameworks, methods, techniques and tools that help deeply address the real needs according to the *equitable design* approach.

- **It enables equal opportunities:** *Equitable design* works on enabling equitable active participation of all people in human activities. It gives independence to all people and enables them to have equal opportunities to participate in every aspect of society; i.e. it helps liberate and enable people. It promotes the inclusion of all people in all life activities.

- **It doesn't prohibit customization:** *Design for equal usability* and *design for equal accessibility* approaches and their established paths point out that *customization* should be attendant *in some way* for equal usability and accessibility *respectively*. Excluding the *one-solution-fits-all* path, the other established paths of the 2 approaches serving under the *context-fit* path show different levels of *customization*. While *segregated proactive* solutions weren't practical in the past, now, considering the current dramatic changes in the world – see sections 2.9.1 and 3.5, and downstream problems and their costly reactive solutions – see sections 2.11.8 and 3.8.5, *segregated proactive solutions may become more practical because they are arranged to come as an integrated part of the system*.

- **It appreciates/values localization:** *Design for equal usability* and *design for equal accessibility* approaches and their established paths point out that *localization* should be attendant *in some way* for achieving their targets. Paths *not* following the *one-solution-fits-all* path rely on localizing the solutions to fit specific contexts and similar (by *considering or/and improving* local conditions or capabilities regarding use and access respectively). Such approaches adopt the *one-solution-fits-all* as the main path and support it with other paths to ensure *inclusiveness* and *practicality*. Following such paths in praxis with considering small-scale local businesses and local culture, and/or relying on local people, businesses, technologies, crafts, designed things, resources and materials, increases the attendance of *localization*[1]. Also, such approaches take us from dominance of ideas to adjustment of ideas on the local levels, and acknowledgment of the value of the local, the diverse and the particular.

- **It adopts diverse solutions when it's needed:** The *equitable design* approach doesn't suggest that it's always possible to design a single solution to address the same needs of all people. Instead, it adopts a variety of actions/solutions to fit the diversity of interaction contexts in the system of meeting human needs. It guides an appropriate design response to the diversity and dynamism of contexts through following the aforementioned diverse paths; i.e. through developing a *family* of designed things or derivatives to provide the best possible contexts coverage. It adopts the *one-solution-fits-all* as the main path and supports it with other paths to ensure *inclusiveness* and *practicality*.

[1] The majority of case studies in the projective study point out that *localization* has been attendant *in some way* for equity. Also, some case studies have shown another form of *localization* via considering small-scale local businesses and local culture; and/or depending on local people, businesses, technologies, crafts, designed things, resources and materials.

3. How to follow the proposed 2 approaches – Paths:

For every established approach, a set of diverse paths has been structured, such paths could be followed by those who practice and manage design to avoid *design exclusion* regarding *usability* and *accessibility*. Every set has its own established paths and every path could be classified either as a *context-fit* path or a *context-improve* path. While the *context-fit* path adopts solutions offered to match the contexts characteristics, the *context-improve* path adopts solutions offered to improve the contexts characteristics.

Improving and preventing deterioration of the personal and environmental characteristics of people's contexts uplift their capabilities and facilitates working on meeting their needs. Rather than working on fitting the contexts characteristics for making designed things fit with the people's capabilities to meet their needs, sometimes, it may be practical and better to improve their contexts characteristics.

The diverse paths can lead to diversity-supportive design and prove that *equitable design* is a realistic goal. Anyway, to achieve this goal, choosing the suitable path or paths will have to be established upon a careful trade-off among them based on functional and economic criteria.

Finally, it's worth mentioning that the *equitable design* approach is a holistic, innovative and socially responsible approach, which in turn constitutes a creative, ethical and organizational challenge for the design, business and decision-making communities.

4. Promoting the 'equitable design' message:

Achieving *equitable design* requires considering the dynamic diversity of the potential interaction contexts in the design process; in turn entails that all *actors* (people who practice, commission or manage design) should acknowledge and adopt the approach of *equitable design*, i.e. acknowledge that diversity is the one true thing that contexts have in common, dynamism is an inevitable matter, and there is a danger of widening the gap among people.

Acknowledging and adopting the *equitable design* approach by all actors requires efforts to raise their awareness (changing their mindsets/attitudes) toward such an approach for promoting the *equitable design message* within the design, business and decision-making communities. For this aim, fundamental keys have been proposed and discussed for raising awareness needed to promote the message of *design for equal usability* and *design for equal accessibility* approaches within the 3 communities or for those whom dynamic diversity of interaction contexts isn't on their radar.

For promoting the *design for equal usability* message, the proposed & discussed keys are:

- Building up the relevant literature
- Actively involving diverse potential end-users in the design process
- Simulating the non-mainstream potential contextual characteristics – Simulation
- Working at the margins (outside the range of average case)
- Going deeply into other disciplines related to the use relation – Interdisciplinary studies
- Varying the design team members – Multi-characteristics design team
- Creating realistic scenarios considering diverse potential use contexts – Scenarios
- Eliminating the fears – Motivations

For promoting the *design for equal accessibility* message, the proposed & discussed keys are:

- Building up the relevant literature
- Actively involving diverse potential consumers in the design process
- Working outside the served elites
- Creating realistic scenarios considering diverse potential access contexts – Scenarios
- Eliminating the fears – Motivations

Discussion in sections 2.11 and 3.8 has clarified the rationale behind these keys and their positive impact on raising awareness of the aimed actors via achieving one or more of the following aims:

  - Providing sufficient reliable relevant knowledge leading to real requirements
  - Developing an empathy towards the underserved people (the excluded majority)
  - Eliminating the fears and doubts about both approaches

Navigation through both sections demonstrates the value of both: *interdisciplinary work* and *co-design*.

The value of interdisciplinary work: *Design permeations* (going deeply) into other disciplines related to individual-designed thing relations through depending on *interdisciplinary* modes of working, studying and knowing play a significant role in reaching the whole knowledge regarding the dynamic diversity of potential interaction contexts, in turn, in raising awareness of the design community and avoiding *design exclusion*.

The value of co-design: Working collaboratively with actors, stakeholders (incl. end-users and consumers), and professionals of other disciplines through *the professionally guided design process* plays a major role in raising awareness of all actors and reinforcing *design inclusion*. Collaborative and integrated forms of design practices based on sharing conversations and ideas with others and considering their inputs are more effective and realistic in design decision-making – see sections 2.11.2, 2.11.5 & 3.8.2. There are some well-developed design approaches such as *PD*, *cooperative design* and *meta-design* that place particular emphasis on participation by diverse stakeholders and actors – on involving people actively in a *co-design* process.

To work well in raising awareness of all actors toward the *equitable design* approach, the above-mentioned keys require suitable supportive frameworks and methods, and consequently appropriate techniques and tools. Researchers are tasked with the mission of finding, choosing, designing and developing suitable frameworks, methods, techniques and tools – according to the *aimed actor* – to support such keys in their mission. Sections 2.11 and 3.8 have reviewed some of the positive signs (considerable and valuable efforts undertaken) regarding some of these keys.

Promoting the *equitable design message* within the design, business and decision-making communities via such keys enhances the possibility of preparing aware, enthusiastic and skilled practitioners regarding *equity in meeting human needs*; in turn, this helps improve the majority's *quality of life*, enhances *independence* and *social inclusion* and eliminates the *socially unsustainable state of the world* regarding *equity in meeting human needs*.

5. Who can put the 'equitable design' approach on the radar?

But who initiates and leads endeavours to put the *equitable design* approach on the radar of all actors? Who should be tasked with the mission of promoting its message within the design, business and decision-making communities – the mission of changing the mindsets of all actors?

As usual, initiations emerge from the voluntary sector; problem owners (the excluded such as older, impaired, poor and rural people); representative organizations of excluded people; and interested persons, progressive staff and activists (belonging to the 3 communities) who are against the kinds of institutional stasis common in design institutions that remain locked into feeding the supply chain of designers adopting the paradigm of *design for the market*. These initiators form pressure groups. They spend time, effort and money to put the convincing ideas and approaches on the radar of the target actors. As soon as their efforts affect the actors, a culture of learning starts to form.

Once the actors acknowledge and adopt the *equitable design* approach, and it's recognized as an essential requirement of *good* and *sustainable* design, its requirements will be of primary consideration, and the actors themselves will develop or demand to develop the relevant established keys and their supportive frameworks, methods, techniques and tools. For example, companies which will adopt this approach would seek to develop some of the established keys, such as the active involvement of the diverse potential end-users and consumers in the design process, simulation of the non-mainstream potential contextual characteristics, and building up the relevant data; and such companies may develop frameworks, methods, techniques and tools for such endeavours. Also, educational institutions of design would seek to develop new modules, curriculums and courses covering every point of this approach; and they may develop the established keys and their supportive frameworks, methods, techniques and tools. For design research and profession, the same applies.

Gradually, the *equitable design* approach would completely permeate the culture of the design, business and decision-making communities.

4.1.2.2. The reciprocal economy – Jumping together:

As has been mentioned before, it would be unreasonable, inefficient and ineffective to call for a *revolution in design* to ensure *equal accessibility* and *usability* without an accompanying *revolution in business* through which design is often practiced and whose primary purpose of *design for the market* is creating designed things for *profit*.

In line with the reality that businesses are *at cross purposes* and that profits often become their first priority, it's logical to use profits as a main motivator to address and encourage businesses to *invest in the underserved* or to consider the *common good* along with the *self -interest*. Profits are an important means to accomplishing other purposes whether serving customers, supporting a cause, developing people or building a better world (Spahn, J.: 2003, p. 3). Here, considering the *common good* doesn't mean engaging in specific social projects. Instead, it refers to creating an economy that is large, growing steadily and reliably, and leaves out the fewest excluded (ibid.: p. 3).

Depending on profits as a motivator is an invitation to renew – not to destroy – the existing dominant model of business which generally focuses on the needs of the self and whose primary purpose of *design for the market* is creating designed things for *profit*. It isn't an invitation to become a social enterprise or to apply commercial strategies to maximize improvements in human well-being at the expense of maximizing profits for shareholders, but it's an invitation to increase profits (achieve the *self-interest*) via achieving the *common good* or to consider both of them, instead of the current form of *capitalism* or the expired form of *communism* theoretically focuses upon the common interest. Sections 2.11.8 and 3.8.5 have argued the fears and defensive assumptions of the business community to prove that there's a direct connection between *equally usable design* and *equally accessible design* respectively on one hand and *profitability* on the other.

What needs to emerge, and in some circles is emerging, is what J. Jeffrey Spahn called a *mutual* or *reciprocal economy* that focuses on the needs of both the *individual* and *collective*. This concept was launched in his paper *A New Capitalist Manifesto? Re-Imagining* Business *in the 21st Century* – 2003. In this paper, he pointed out the need and value of striking a balance between *profits* and the *core purpose* – implementing profits via achieving the core purpose. This economic model assumes that *self-interest* and the pursuit of the *common good* or the wealth of all nations can be mutually enhanced. In this way, it integrates *communism* emphasis on the collective and *capitalism* emphasis on the individual (ibid.: p. 3). The assumption at work here is that thinking and acting, philosophy and business, ethics and economics, meaning and money, purpose and profits, and cooperation and competition aren't mutually exclusive, but mutually enhancing notions (ibid.: p. 2).

The key to change behaviour, whether of an individual or a corporate, often lies in recognition and reexamination of why we do what we do, i.e. defining the purpose which is a more intangible dimension and perhaps for that reason is often overlooked. (ibid.: p. 1)

> *Far from being a naive unrealistic pipe dream, reciprocal economies do exist. In fact they thrive. Breakthrough research at Harvard and Stanford indicates that corporations experiencing exceptional long term financial success are mutual economies. These global enterprises have figured out a way to maximize profits and serve the common good. ………. These enterprises such as Canon, Johnson & Johnson, Marriott and Sony have embraced the challenge of enhancing the well being of human life through business.* (ibid.: p. 3)

The emergence of a reciprocal economy is a manifestation of a wider human phenomenon called *consilience* which literally means *jumping together*. It describes the occurrence of 2 seemingly mutually exclusive ideas or categories becoming not only compatible but mutually enhancing; e.g. the cover of a Newsweek edition has read, *Science Finds God*. In the case of the mutual economy, common good and self-interest, philosophy and business, ethics and economics, meaning and money, and cooperation and competition are jumping together. (ibid.: p. 6)

In doing this, businesses serve at the lowest levels of people's capabilities regarding access and use; and the underserved people would be treated as customers rather than as recipients of charity or asking for interventions.

Additionally, such a model represents a chance for business, government, and civil society to join together in a common cause. Indeed, it can dissolve the conflict between proponents of the existing dominant model of business and proponents of social sustainability. (Prahalad, C.: 2002, p. 14)

Motivated by gaining profits and guided by the successful case studies regarding equity – see sections 2.11.8.1 and 3.8.5.1, companies could invest in and design for *the underserved* to address opportunities in their markets. The *mutual economy* is a business opportunity to do well and do the good. This model of businesses could promote *CSR*, and help break out the revolution required in business which could pave the way to the revolution required in design to break out. Thus, the *mutual economy* could be effective in covering at least 3 areas of the proposed *model of SRD*: *meeting human needs*, *equity in meeting human needs*, and *profits*.

This requires approaches fundamentally different from those serving in the *average case* and *over-consumers*' markets. Companies can't exploit these new opportunities without radically rethinking how they go to market. Regarding *equal accessibility*, the following suggests some areas where an entirely new perspective is required to create profitable markets in the *under -consumers*' segment (Prahalad, C.: 2002).

- **Profitability:** 'It will demand a new level of capital efficiency and new ways of measuring financial success. Companies will be forced to transform their understanding of scale, from a *bigger is better* ideal to an ideal of highly distributed small-scale operations married to world-scale capabilities' (ibid.: p. 2). Specifically, the *under-consumers' market* 'isn't a market that allows for the traditional pursuit of high margins; instead, profits are driven by volume and capital efficiency' (ibid.: p. 5). Margins are likely to be low (by current norms), but unit sales can be extremely high – achieve profit via low margins and high volume (investment intensity) (ibid.: p. 5). 'Managers who focus on gross margins will miss the opportunity at the bottom of the pyramid; managers who innovate and focus on economic profit will be rewarded' (ibid.: p. 5).
- **Environmental sustainability:** It'll require companies to adopt the up-to-date strategies and technologies of *environmental sustainability* (reduction in consuming resources & producing emissions) in the *under-consumers' markets* as a logical entrance to address and succeed in these markets. They should raise the slogan that, we avoid repeating the environmental mistakes of the *over-consumers' markets* (resource-, energy- and emission-intensive markets), and we protect you and your future.

- **Organization:** It'll require companies to build a different *organizational infrastructure*. This includes:
    - building a local base of public and political support to overcome any potential problems (ibid.: p. 12);
    - reorienting research and development (R&D) and market research to focus on the needs of the under-consumers – by region and by country (ibid.: p. 12);
    - forming new alliances[1] with local entities to gain insight into local culture and knowledge, secure preferred or exclusive access to a market or raw materials, and gain local support (ibid.: p. 13);
    - modifying production and distribution systems through engineering *unusual market infra-structures*;
    - increasing employment intensity among the local poor to raise their income and enable them to be new customers (ibid.: p. 13);

These 5 organizational elements are clearly interrelated and mutually reinforcing.

[1] Alliances may be with local firms and cooperatives, NGOs, and governments. (Prahalad, C.: 2002, p. 13)

4.2. Towards a practicable SRD model:

By conceptually and methodologically adopting the *equitable design* approach to ensure *inclusiveness* and *practicality*, design as a means would be actually committed to its social responsibility regarding *equity in meeting human needs* and implicitly regarding *meeting human needs* (the 2nd and 1st area of the *proposed model of SRD* – section 1.4). Additionally, it would logically, smoothly and effectively embrace the recently emerged area of SRD concerned with *tackling the most pressing issues* (*the wicked problems*) in such a model.

All aforementioned case studies have demonstrated the real value of design and how it could improve the lives of *the underserved* around the world, and that it can regain social relevance. In addition, the case studies and expressive examples following the *context-improve* path have shown how design has the power to be a part of the solution to global challenges like *illiteracy*, *poor healthcare*, *unemployment* and *poverty*. They could be tackled while design practices aim to *meet human needs equally*. So, *tackling the wicked problems* shouldn't be classified as a separate SRD area but as a way of serving 2 areas of the proposed model of SRD: *equity in meeting human needs* and implicitly *meeting human needs* – fig. 4.1.

Recognizing such issues as an expression of the low characteristics related to empowerment and use of people's contexts, recognizing their negative effects on people's abilities levels of access and use which hinder working on meeting their human needs, and approaching the *context-improve* path[1] (improving people's contexts characteristics and uplifting their capabilities) to prevent such negative effects on *equity in meeting human needs*, help tackle such *pressing issues* and facilitate working on *equally meeting human needs*.

Contrary to the dominant paradigm in which businesses – thus design practices – often avoid involvement in the area of *tackling the wicked problems*, the *equitable design* approach ensures that such problems would be in the circle of business attention because they would not be seen as isolated from *meeting human needs* (the main SRD area) via which businesses stay alive – fig. 4.2.

---

[1] As mentioned earlier, we resort to such a path at the expense of the *context-fit* path when it's *more practical* than working on fitting the contexts characteristics to meet people's needs. Rather than working on fitting the contexts characteristics for making designed things fit with the people's capabilities to meet their needs, sometimes, it may be practical and better to improve the contexts characteristics.

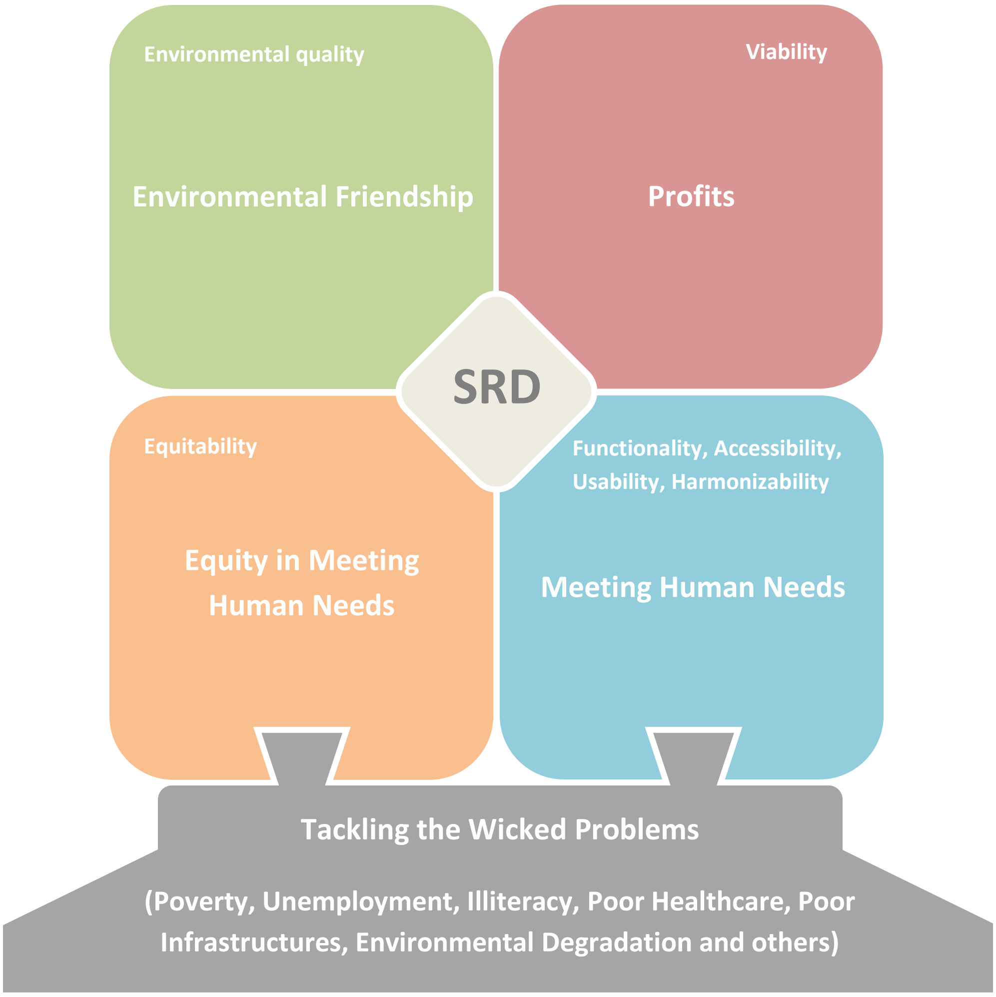


Fig. 4.1: An illustration of the *modified SRD model* classifying and embracing '*tackling the wicked problems'* as a way of serving 2 of its main areas, not as a separate new SRD area for ensuring that such problems would be in the circle of business attention, thus of design practices.

Thus, such a model could unify the opposing parties to work in the same direction – on the one side businesses and on the other side the well-intentioned NGOs, communities, local governments and multilateral development agencies. Also, it could prevent the division of the design paradigm – accordingly, design practitioners – between *serving the business* and *tackling the wicked problems*.

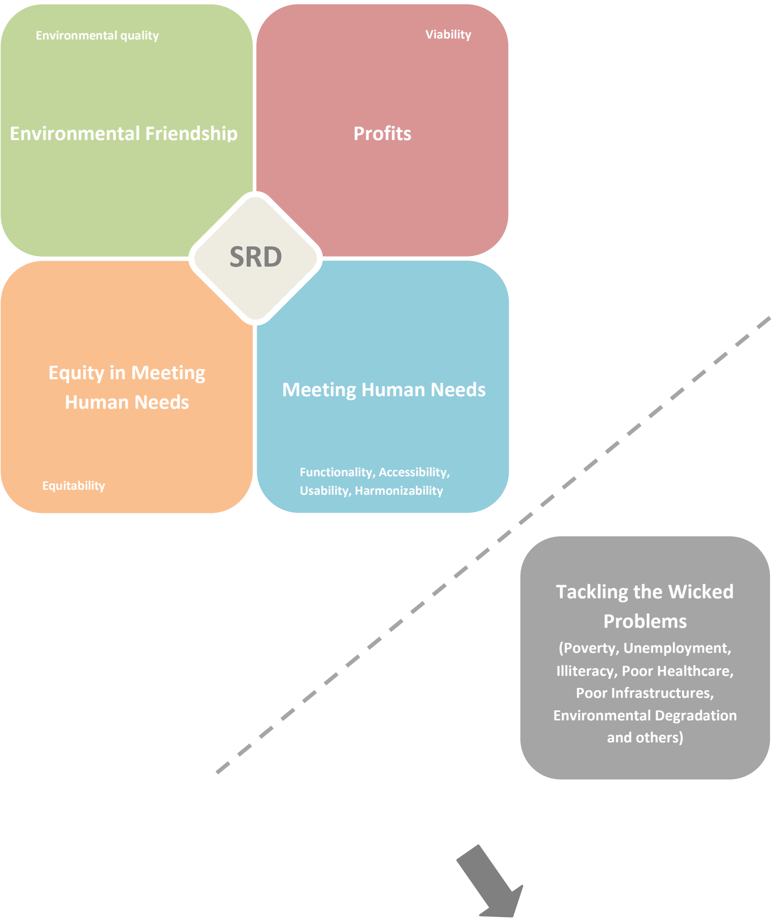


Fig. 4.2: From avoiding to embracing the new SRD area (*tackling the wicked problems*) in the *proposed SRD model*.

By *adopting the equitable design* approach (concept and paths), **design** could be effective in covering the *new area of SRD* beside 2 areas of the proposed model: *meeting human needs*, and *equity in meeting human needs* – fig. 4.3.

By *adopting the equitable design* approach (concept and paths), the **mutual economy** could be effective in covering the *new area of SRD* beside 3 areas of the proposed model: *meeting human needs*, *equity in meeting human needs*, and *profits* – fig. 4.3.

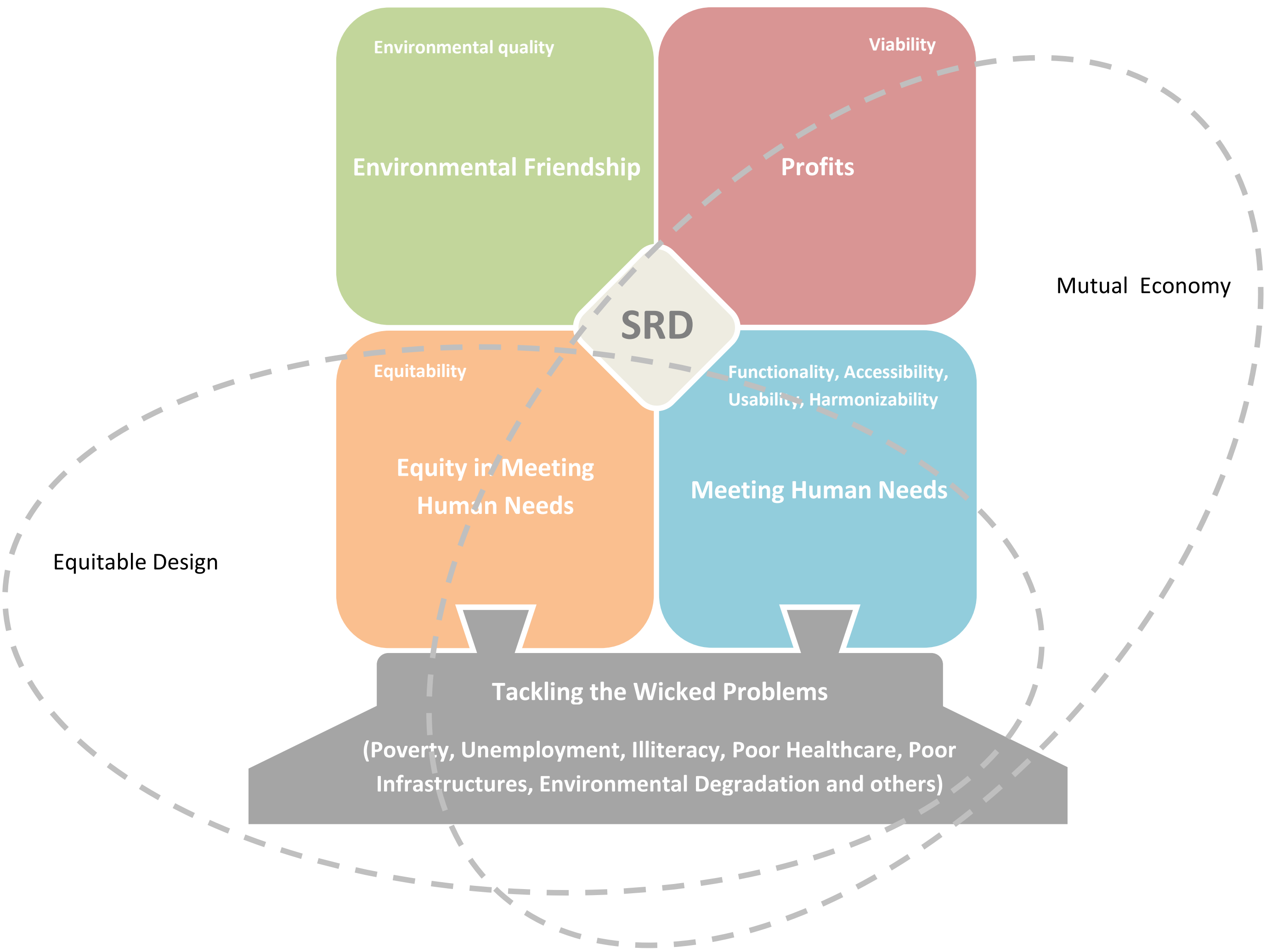


Fig. 4.3: An illustration of the covered areas of the *modified SRD model* by the *equitable design* approach and the *mutual economy*.

4.3. Mapping the word 'social' in the design field:

Navigating through the study demonstrates that the word '*social*' could be paired with the word '*design*' to express various meanings. Therefore, the term '*social design*' embraces more than one perspective which can be defined according to the action at hand. Such perspectives could be defined in:

- **Designing a social thing – An outcome:** Designing things that positively affect people's social life or contribute to satisfying the social human needs (love & belonging) is a social matter. Such things are characterized as *social things*. Designed things helping people form *social relations* with others in the form of partnerships, families, groups or communities are valued for their social importance alongside their usefulness; e.g. common games, furniture and spaces, and communication devices and networks.
- **Designing for society – A role and responsibility:** Designing for improving the society is a social matter. It reflects the *social responsibility of design* defined in the following areas: meeting human needs, equity in meeting human needs (social inclusion), environmental friendship, profits, and tackling the most pressing issues – see sections 1.4 and 4.2. Taking into account that the last area shouldn't be seen as isolated from the 1st and 2nd area – fig. 4.1 – to ensure that it would be in the attention circle.
- **Designing/working together – A method:** Working collaboratively with other actors, stakeholders (incl. users & consumers), and professionals of other disciplines *through the design process* is a social matter. Such a form of *social design* is *methodic*. Collaborative and integrated forms of design practices based on sharing conversations and ideas with others and considering their inputs are more effective and realistic in design decision -making, thus, in setting and solving the problems – see sections 2.11.2, 2.11.5 and 3.8.2.

This variety of perspectives under the term '*social design*' frequently causes confusion while using it. So, it isn't suitable to still use it without an accompanying sign to what perspective it's intended, or it will be better to assign it to only express the perspective meaning the *social responsibility of design*.

4.4. Contribution to Knowledge and desired implications:

To challenge our understanding of design practices consequences and reframe our conceptions of designed things, this study has worked to provide a solid socio-theoretical substructure for the *design theory* to regain social relevance. For this, the study has been based on *theoretical* and *projective* research to be able to provide effective knowledge that may be of value in refining the *design theory* and growing the scientific knowledge, and enable us to think about design in new ways and guide the new design practices to produce *socially sustainable design*.

Regarding the verified and generalized *theoretical knowledge* addressing social considerations, identifying the weaknesses and failures of design in this context, and acknowledging concrete concepts and ideas, it may be of value and may contribute to the growth of scientific knowledge and accordingly achieve a more comprehensive and deeper understanding of the accurate anatomy of the individual-designed thing relations of use and access, the deep clarification of the dynamic diversity of people's contexts, the accurate description of the socially unsustainable results of our current design paradigm (design exclusion), and the verified cause related to design practices behind this exclusion.

Regarding the structured and established *projective knowledge* based on the new verified and generalized theoretical knowledge and being inherently more socially sustainable, it may be of value and applicably useful in helping avoid design exclusion and tackle the pressing and complex problems of a world made socially unsustainable. Also, it may contribute to the growth of scientific knowledge, which in turn guides the new design practices to address the *agenda of sustainability* regarding *social equity in meeting human needs – equity within generations* – and pave the way for shaping humans' future in a socially sustainable fashion. The structured and established projective knowledge is represented in the *design for equal usability* and *design for equal accessibility* approaches, their supporting *paths*, and the *fundamental keys* structured and clarified for raising awareness needed to promote messages of these approaches within the *design, business and decision-making communities*.

Finally, such a broader scope of *knowledge* introduced in this study may offer new perspectives to tackle *social inequity in meeting human needs*, and consequently ensure a socially sustainable world.

In this regard, the study may prove usefulness in *design education*. It may reinforce the educational curriculums of design to help *students* – forming the foundation of the future design community – know how to achieve *social sustainability* regarding *equity in meeting human needs* depending on its theoretical and projective knowledge. Using this study and considering its sequence, students may start ideating by learning and becoming aware of the accurate anatomy of the individual-designed thing relations of use and access, the deep clarification of the dynamic diversity of people's contexts, the accurate description of the socially unsustainable results of our current design paradigm (design exclusion), and the verified cause related to design practices behind this exclusion. Additionally, students may benefit from the established projective knowledge inherently more socially sustainable, and which we consider that it can help deliver more *effective equal* designs.

In *design research*, we believe that this study will help researchers rethink and question our understanding of design practices consequences, and our conceptions and pre-conceptions of unfamiliar contexts. Although we are aware that this study is one proposal to rectify the path of design practices, we would like to invite researchers to benefit from it, adapt it and improve it with their own experiences and research in the field. Also, this study provides a wide space for further research, especially needed for creating and developing suitable frameworks, methods, techniques and tools to support design practitioners in identifying the real requirements according to the *equitable design concept* throughout all phases of the design process, and others to serve and support the fundamental keys established for raising awareness of all actors toward the *equitable design approach*.

Regarding *design practitioners* and members of *business* and *decision-making communities*, the knowledge presented can contribute to raising their awareness regarding deficiencies in design practices behind the *social unsustainability state of the world*, and how to avoid recurrence of them. In turn, this can contribute to rectifying their conceptions about the quality of *design practices*, *economics* and *politics*.

4.5. Limitations and recommendations for further research:

In its current state, the study has covered only 2 of the 3 qualities via which the quality of *equitability* could be achieved. The study has been limited to the *accessibility* and *usability* qualities at the expense of the *harmonizability* quality. In this study, only *design exclusion* resulting from *unequal usability* and *accessibility*, and the established approaches '*design for equal usability*' and '*design for equal accessibility*' responding to this exclusion, have formed the overall study content. For design exclusion resulting from *unequal harmonizability*, and the proposed approach '*design for equal harmonizability*' reacting to this exclusion, further research is required to complete the whole picture of the *equitable design* approach aiming to avoid the *social inequity in meeting human needs*. Such prospective research could follow the sequence of the current study on the theoretical and projective level, but according to the details of the *individual-designed thing relation of harmony*.

Also, further research is needed to create and develop suitable frameworks, methods, techniques and tools to support design practitioners to *identify* the real requirements according to the *equitable design* concept in the initial phases of the design process and to *integrate* the consideration of dynamic diversity of interaction contexts throughout all phases of the design process. As has been mentioned before, traditional frameworks, methods, techniques and tools serving the dominant design paradigm are clearly inappropriate since they can't accommodate diversity and dynamism.

Additionally, further research is needed to create and develop suitable frameworks, methods, techniques and tools for serving and supporting the fundamental keys established for raising awareness of all actors toward the *equitable design* approach.

5. References

5. References

aajewelry.com/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/n/e/newfinal_1.jpg

AFA: *About Alzheimer's Disease*. Available at: www.alzfdn.org/AboutAlzheimers/definition.html Accessed February 15, 2015

AfH: 2012, *Annual Report 2011 – 2012*.

agirlsguidetocars.com/fords-third-age-suit/ Accessed November 19, 2018

Agnihotri, A.; Purwar, B.; Jeebun, N. and **Agnihotri, S.:** 2005, Determination of sex by hand dimensions, in: *The Internet Journal of Forensic Science*, vol. 1, no. 2.

Alwafd.org: 2016, *Census: 8.6 million licensed vehicles in Egypt*, April 26. Available at: http://alwafd.org/ اقتصاد/1148983-الإحصاء-8-6-مليون-مركبة-مرخصة-في-مصر Accessed November 29, 2016

American Psychological Association: *Older Adults' Health and Age-Related Changes, Reality versus Myth*. Available at: www.apa.org/pi/aging/resources/guides/older.aspx Accessed February 15, 2015

annewilsonschaef.com Accessed October 29, 2020

anthillonline.com/why-is-profit-for-purpose-so-darn-cool/ Accessed November 18, 2018

Appadurai, Arjun: 2008, Globalization, in: *Design Dictionary: Perspectives on Design Terminology*, (Erlhoff, Michael and Marshall, Tim, eds.), pp. 193: 196, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Aranda-Jan, Clara B., Jagtap, Santosh, and **Moultrie, James:** 2016, Towards a framework for holistic contextual design for low-resource settings, in: *International Journal of Design*, 10(3), pp. 43: 63.

archdaily.com/351354/francisco-perez-anampa-school-architecture-for-humanity Accessed June 3, 2019

architectureforhumanity.org/node/1998 Accessed October 13, 2015

Ashby, William Ross: 1958, Requisite variety and implications for control of complex systems, in: *Cybernetica* 1, pp. 83: 99.

Ashok, Mahima and **Jacko, Julie A.:** 2009, Dimensions of user diversity, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 4-1: 4-15, CRC Press, Taylor & Francis Group, Boca Raton/London/New York.

averageheight.co/average-female-height Accessed November 11, 2014

averageheight.co/average-female-height-by-country Accessed November 11, 2014

averageheight.co/average-male-height Accessed November 11, 2014

averageheight.co/average-male-height-by-country Accessed November 11, 2014

Banaji, Mahzarin R. and **Greenwald, Anthony G.:** 2013, *Blindspot: Hidden Biases of Good People*, Delacorte Press, Random House Publishing Group, New York.

Bhamra, Tracy and **Lofthouse, Vicky:** 2007, *Design for sustainability: a practical approach*, Gower Publishing Limited, England.

Birke, Lynda: 2001, In pursuit of difference: Scientific studies of women and men, in: *The Gender and Science Reader*, (Leaderman, Muriel and Bartsch, Ingrid, eds.), Routledge, New York, pp. 309: 321.

blog.4wheelonline.com/2015/06/15/fords-third-age-suit-aids-in-the-simulation-of-elderly-driving/ Accessed November 19, 2018

Bobjer, O.: 2004, *Friction and Discomfort in the Design and Use of Hand Tools-Exposure to Textures at Different Loads and Velocities with Reference to Contamination*, Doctoral thesis (Department of Design and Technology, Loughborough University).

Boradkar, Prasad: 2010, *Designing Things – A Critical Introduction to the Culture of Objects*, Berg, Oxford/New York.

Bourne, R.R.A.; Flaxman, S.R.; Braithwaite, T.; Cicinelli, M.V.; Das, A.; Jonas, J.B.; et al.: 2017, Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: A systematic review and meta-analysis, in: *The Lancet Glob Health*, 5(9), pp. e888: e897.

Boyd, William Clouser: 1950, *Genetics and the Races of Man: An Introduction to Modern Physical Anthropology*, Little, Brown and Co., Boston.

Bremner, Craig: 2008, Usability, in: *Design Dictionary: Perspectives on Design Terminology,* (Erlhoff, Michael and Marshall, Tim, eds.), pp. 425: 428, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Bromley, Dennis Basil: 1988, *Human Ageing: An Introduction to Gerontology*, 3rd edition, Penguin Books, UK.

BS 7000-6: 2005, *Guide to Managing Inclusive Design*, British Standards Institution, London.

Burnside, I. M., Ebersole, P. and **Monea, H. E.:** 1979, *Psychosocial Caring throughout the Lifespan*, McGraw Hill, New York.

businessdictionary.com/definition/for-profit-organization.html#ixzz2VvKTsSUg Accessed June 23, 2013

Cardoso, Carlos and **Clarkson, John:** 2007, User simulation in product evaluation, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 197: 210, Gower Publishing Limited.

Cardoso, Carlos and **Clarkson, John:** 2012, Simulation in user-centred design: Helping designers to empathise with atypical users, in: *Journal of Engineering Design*, vol. 23 (1), pp. 1: 22.

Carroll, John M.: 2006, Dimensions of participation in Simon's design, in: *Design Issues*, vol. 22, no. 2, pp. 3: 18.

Cassim, Julia and **Dong, Hua:** 2007, Designer education: Case studies from graduate partnerships with industry, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 71: 87, Gower Publishing Limited.

Cassim, Julia and **Dong, Hua:** 2007, Empowering designers and users: Case studies from the DBA inclusive design challenge, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 89: 109, Gower Publishing Limited.

Cassim, Julia; Coleman, Roger; Clarkson, John and **Dong, Hua:** 2007, Towards inclusion: Future challenges, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 229: 239, Gower Publishing Limited.

Cassim, Julia; Coleman, Roger; Clarkson, John and **Dong, Hua:** 2007, Why inclusive design? In: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 11: 21, Gower Publishing Limited.

CDC: *Blindness and Vision Impairment*. Available at:
www.cdc.gov/healthcommunication/ToolsTemplates/EntertainmentEd/Tips/Blindness.html
Accessed February 15, 2015

cdc.gov/aging/pdf/cognitive_impairment/cogimp_poilicy_final.pdf

cdn.astrojewelry.com/api/i/28368948/520/32_media_catalog_product_r_x_rx8141.jpg

Chick, Anne and **Micklethwaite, Paul:** 2011, *Design for Sustainable Change – How Design and Designers Can Drive the Sustainability Agenda*, An AVA Book.

Clarkson, John: 2007, Countering design exclusion – Theory and practice, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 165: 180, Gower Publishing Limited.

Clarkson, John; Cardoso, Carlos and **Hosking, Ian:** 2007, Product evaluation: Practical approaches, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 181: 196, Gower Publishing Limited.

Clarkson, John; Coleman, Roger; Hosking, Ian and **Waller, Sam:** 2007, *Inclusive Design Toolkit*, University of Cambridge, UK. Available at:
www-edc.eng.cam.ac.uk/downloads/idtoolkit.pdf

Clarkson, John; Coleman, Roger; Keates, Simeon and **Lebbon, Cherie:** 2003, *Inclusive Design: Design for the Whole Population*, Springer-Verlag, London.

Clasen, Thomas F.; Roberts, Ian G.; Rabie, Taber; Schmidt, Wolf-Peter and **Cairncross, Sandy:** 2009, *Interventions to Improve Water Quality for Preventing Diarrhoea (Review)*, The Cochrane Collaboration, John Wiley & Sons, Ltd.

Coleman, Roger: 1999, Inclusive design – Design for all, in: *Human Factors in Product Design – Current Practice and Future Trends*, (Green, W. S. and Jordan, P. W., eds.), pp. 171: 181, CRC Press, Taylor & Francis Group, Boca Raton, London, New York.

Coleman, Roger; Clarkson, John; Dong, Hua and **Cassim, Julia:** 2007, *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, Gower Publishing Limited.

Coleman, Roger; Clarkson, John; Goodman, Jog; Hosking, Ian; Sinclair, Kay and **Waller, Sam:** 2007, Introduction, in: *Inclusive Design Toolkit*, (Clarkson, John; Coleman, Roger; Hosking, Ian and Waller, Sam, eds.), pp. 1-1: 1-55, University of Cambridge, UK. Available at:
www-edc.eng.cam.ac.uk/downloads/idtoolkit.pdf

Coleman, Roger; Clarkson, John; Hosking, Ian; Sinclair, Kay; Waller, Sam and **White, Matthew:** 2007, Inclusive design process, in: *Inclusive Design Toolkit*, (Clarkson, John; Coleman, Roger; Hosking, Ian and Waller, Sam, eds.), pp. 2-1: 2-61, University of Cambridge, UK. Available at:
www.edc.eng.cam.ac.uk/downloads/idtoolkit.pdf

Coleman, Roger; Topalian, Alan; Clarkson, John and **Dong, Hua:** 2007, The business case, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 33: 55, Gower Publishing Limited.

Collard, Rose M.; Boter, Han; Schoevers, Robert A. and **Oude Voshaar, Richard C.:** 2012, Prevalence of frailty in community-dwelling older persons: A systematic review, in: *Journal of the American Geriatrics Society*, 60 (8), pp. 1487: 1492.

Conner, Michael G.: 1999-2000, *Understanding the Difference between Men and Women*. Available at:
http://oregoncounseling.org/ArticlesPapers/Documents/DifferencesMenWomen.htm

Cook, Albert M. and **Hussey, Susan M.:** 1995, *Assistive Technologies: Principles and Practice*, Mosby-Year Book, St. Louis, MO.

Cooney, Craig A.; Dave, Apurva A. and **Wolff, George L.:** 2002, Maternal methyl supplements in mice affect epigenetic variation and DNA methylation of offspring, in: *Journal of Nutrition*, 132 (8), pp. 2393S: 2400S. Available at:
http://jn.nutrition.org/content/132/8/2393S.long

cooperhewitt.org/

Crutzen, Paul J. and **Stoermer, Eugene F.:** 2000, The anthropocene, in: *The International Geosphere-Biosphere Programme (IGBP): A Study of Global Change of the International Council for Science (ICSU)*, IGBP newsletter no. 41, p. 17& 18, May.

CUD: 1997, *The Principles of Universal Design*, Version 2.0, Raleigh: North Carolina State University. Available at:
https://projects.ncsu.edu/ncsu/design/cud/pubs_p/docs/poster.pdf and
https://projects.ncsu.edu/ncsu/design/cud/about_ud/udprinciplestext.htm Accessed March 23, 2018

D-Rev: 2012, *Annual Report*.

d-rev.org/projects/brilliance/need.html Accessed June 23, 2013

d-rev.org/projects/remotion/need.html Accessed June 23, 2013

data.worldbank.org/

data.worldbank.org/indicator

data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2022&locations=EG&start=1961

Davey, Caroline L.; Wootton, Andrew B.; Thomas, Angharad; Cooper, Rachel and **Press, Mike:** 2005, Design for the surreal world? A new model of socially responsible design, in: *The Proceedings of the 6th International Conference of the European Academy of Design, EAD06*, University of the Arts Bremen, March 29:31, Bremen, Germany.

Department of Communities, Child Safety and Disability Services: 2012, *Ageing: Myth and Reality*. Available at:
www.qld.gov.au/seniors/documents/retirement/ageing-myth-reality.pdf

designforall.org/ Accessed November 19, 2018

designforall.org/design.php Accessed November 19, 2018

designingwithpeople.rca.ac.uk/wp-content/uploads/CSdexterity-FactoryFactoryWares.pdf Accessed November 19, 2018

designother90.org/solution/10x10-sandbag-house/ Accessed June 23, 2013

designother90.org/solution/floating-community-lifeboats/ Accessed June 23, 2013

designother90.org/solution/lifestraw/ Accessed June 23, 2013

designother90.org/solution/millennium-school-bamboo-project/ Accessed June 23, 2013

designother90.org/solution/one-laptop-per-child/ Accessed June 23, 2013

designother90.org/solution/plastic-formwork-system/ Accessed June 23, 2013

designother90.org/solution/q-drum/ Accessed June 23, 2013

designother90.org/solution/whirlwind-roughrider/ Accessed March 23, 2018

dfaeurope.eu/ Accessed November 19, 2018

Diefenthaler, Annette: 2008, Problem solving, in: *Design Dictionary: Perspectives on Design Terminology*, (Erlhoff, Michael and Marshall, Tim, eds.), p. 307& 308, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Dobie, Robert A. and **Van Hemel, Susan:** 2004, *Hearing Loss: Determining Eligibility for Social Security Benefits*, National Academies Press (US), Washington (DC). Available at:
www.ncbi.nlm.nih.gov/books/NBK207834/ and www.nap.edu/read/11099

Dong, Hua; Pullin, Graham; Nielsen, Ingelise; Benktzon, Maria; Bobjer, Olle and **Tanner, Barry:** 2007, Market advantage: Practitioners' viewpoints, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 57: 70, Gower Publishing Limited.

Dresner, Simon: 2008, *The Principles of Sustainability*, 2nd edition, Earthscan, London, Sterling, VA.

Dreyfuss, Henry: 1960, *The Measure of Man: Human Factors in Design*, Whitney Library of Design, New York.

DTI: 2006, *The Equipment Needs of Consumers Facing Most Difficulty Switching to Digital TV*, Research Conducted by Sagentia Assisted by Cambridge Engineering Design Centre, London. Available at: www.digitaltelevision.gov.uk/publications

earthbagbuilding.com/articles/eco-beam.htm Accessed July 6, 2014

EIDD – Design for All Europa. Available at: dfaeurope.eu/ and dfaeurope.eu/what-is-eidd-dfa-europe/ Accessed March 23, 2018

EIDD Stockholm Declaration: 2004. Available at: dfaeurope.eu/wp-content/uploads/2014/05/stockholm-declaration_english.pdf Accessed March 23, 2018

Ellis, Lee et al.: 2008, *Sex Differences: Summarizing More Than a Century of Scientific Research*, Psychology Press, Taylor & Francis Group, LLC.

Emiliani, Pier Luigi: 2009, Perspectives on accessibility: From assistive technologies to universal access and design for all, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 2-1: 2-18, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

Emilson, Anders; Seravalli, Anna and **Hillgren, Per-Anders:** 2011, Dealing with dilemmas: Participatory approaches in design for social innovation, in: *Swedish Design Research Journal*, no. 1, pp. 23: 29.

en.goldenmap.com/Optare_Alero

Encyclopaedia Britannica: *Sexism*, Online Academic Edition, 2015. Accessed March 19, 2016

European Commission: *The Situation in the EU*. Available at: http://ec.europa.eu/justice/gender-equality/gender-pay-gap/situation-europe/index_en.htm

Facchini, François and **Melki, Mickaël:** 2011, *Ideology and Cultural Change: A Theoretical Approach*, Association for the Study of Religion, Economics & Culture, ASREC annual meeting, April 7: 10, Hyatt Regency, Crystal City (Washington DC).

FCA: 2013, *Incidence and Prevalence of the Major Causes of Brain Impairment*. Available at: www.caregiver.org/incidence-and-prevalence-major-causes-brain-impairment

Ford, M.: 1993, Coping again: Better sight for elderly people with central vision loss, in: *Broadcasting Support Services*, 91, pp. 6: 28.

Feo, Roberto; Hurtado, Rosario and Optimastudio: 2008, *Diseños para Todos – Designs for All*, Madrid.

Forman, D.E.; Berman A.D.; McCabe C.H.; Baim D.S. and **Wei, J.Y.:** 1992, PTCA in the elderly: The "young-old" versus the "old-old", in: *Journal of the American Geriatrics Society*, 40 (1), pp. 19: 22.

Forrester Research, Inc.: 2003, *The Wide Range of Abilities and Its Impact on Computer Technology*, a study commissioned by Microsoft and conducted by Forrester Research, Inc.

Fry, Tony: 2009, *Design Futuring – Sustainability, Ethics, and New Practice*, Berg, Oxford & New York.

Fuad-Luke, Alastair: 2009, *Design Activism – Beautiful Strangeness for a Sustainable World*, Earthscan Publications Ltd, London & Sterling, VA.

Fulton Suri, Jane and **Marsh, Matthew:** 2000, Scenario building as an ergonomics method in consumer product design, in: *Applied Ergonomics* (31), pp. 151: 157.

Fundación Prodintec: 2010, *Diseño para Todos*, Spain.

furnace.squarespace.com/alero-csv/ Accessed June 23, 2013

fuseproject.com/category-1-product-3 Accessed June 23, 2013

fuseproject.com/study-overview-3 Accessed June 23, 2013

Gazzaniga, Michael S.; Ivry, Richard B. and **Mangun, George R.:** 2009: *Cognitive Neuroscience: The Biology of the Mind*, 4th edition, W.W. Norton & Company, New York.

Glaeser, Edward: 2011, *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*, Penguin Books.

globalfootprints.org Accessed May 9, 2018

Goldsmith, Selwyn: 1963, *Designing for the Disabled*, Royal Institute of British Architects, London.

Grammenos, D.; Savidis, A. and **Stephanidis, C.:** 2005, UA-Chess: A universally accessible board game, in: *Universal Access in HCI: Exploring New Interaction Environments (Volume 7 of the Proceedings of HCI International 2005)*, (Stephanidis, C., ed.), Mahwah, NJ: Lawrence Erlbaum Associates.

Gregor, Peter; Newell, Alan F. and **Zajicek, Mary:** 2002, Designing for dynamic diversity: Interfaces for older people, in: *The Proceedings of the 5th International ACM Conference on Assistive Technologies (ASSETS 2002)*, July 8: 10, Edinburgh, Scotland, pp. 151: 156, ACM Press, New York. Available at: http://projects.computing.dundee.ac.uk/UTOPIA/publications/Designing%20for%20Dynamic%20Diversity%20(with%20Mary%20Z).pdf

Guinness World Records. Available at: www.guinnessworldrecords.com Accessed November 11, 2014

Hardyck, Curtis and **Petrinovich, Lewis F.:** 1977, Left-Handedness, in: *Psychological Bulletin*, vol. 84 (3), May 1977, pp. 385: 404. Available at: www.ikhebeenvraag.be/mediastorage/FSDocument/36/Hardyck-385.pdf

Haslinger, Susanne: 2008, Social, in: *Design Dictionary: Perspectives on Design Terminology*, (Erlhoff, Michael and Marshall, Tim, eds.), pp. 366: 369, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Hawthorn, D.: 2000, Possible implications of aging for interface designers, in: *Interacting with Computers*, vol. 12, issue 5, pp. 507: 528.

Hearing Loss Association of America: *Basic Facts about Hearing Loss*. Available at: www.hearingloss.org/content/basic-facts-about-hearing-loss Accessed February 15, 2015

heightadjustabledesks.com Accessed October 29, 2020

Herling, Claudia: 2008, Need, in: *Design Dictionary: Perspectives on Design Terminology* (Erlhoff, Michael and Marshall, Tim, eds.), p. 267& 268, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Heylighen, Francis and **Joslyn, Cliff A.:** 2001, The law of requisite variety, in: *Principia Cybernetica Web*, (Heylighen, F.; Joslyn, C. and Turchin, V., eds.), Principia Cybernetica, Brussels. Available at: http://pespmc1.vub.ac.be/REQVAR.html

HGP: 2003, *Minorities, Race, and Genomics*. Available at: http://web.ornl.gov/sci/techresources/Human_Genome/elsi/minorities.shtml

hisco.com/UserFiles/Images/Products/lindstrom-30425_rx8000_DV_WebXL.jpg

home.bt.com/tech-gadgets/ford-third-age-suit-11364044636148 Accessed November 19, 2018

hultafors.co.uk/about-us/ Accessed March 23, 2018

humancentereddesign.org/ Accessed March 23, 2018

hermanmiller.com/products/seating/office-chairs/aeron-chairs/ Accessed October 29, 2020

hermanmiller.com/products/seating/office-chairs/aeron-chairs/product-images/ Accessed October 29, 2020

i2.wp.com/anguloconsulting.com/wp-content/uploads/2017/05/ikea-height-adjustable-desk-uk.jpg

iaud.net/global/ Accessed March 23, 2018

iaud.net/global/conference/ Accessed March 23, 2018

idea.ap.buffalo.edu/ Accessed March 23, 2018

idealist.org/view/business/Zcb3XxtPxWSP/ Accessed June 23, 2013

ideorg.org/OurTechnologies/CeramicWaterFilter.aspx Accessed June 23, 2013

idrc.ocadu.ca/ Accessed March 23, 2018

idrc.ocadu.ca/index.php/resources/idrc-online/library-of-papers/443-whatisinclusivedesign Accessed March 23, 2018

IFC: *Safe Water for All: Harnessing the Private Sector to Reach the Underserved*, Washington, US.

innerbody.com Accessed February 15, 2015

inclusivedesigntoolkit.com Accessed November 19, 2018

inclusivedesigntoolkit.com/case_studies/case_studies.html Accessed November 19, 2018

inclusivedesigntoolkit.com/promotionpres/promotionpres.html Accessed November 19, 2018

inclusivedesigntoolkit.com/tools_simulation/ Accessed November 19, 2018

inclusivedesigntoolkit.com/whatis/whatis.html Accessed November 19, 2018

inclusivedesigntoolkit.com/why/why.html Accessed November 19, 2018

International Union for Conservation of Nature and Natural Resources: 1980, *World Conservation Strategy: Living Resources Conservation for Sustainable Development*, Gland, Switzerland: IUCN.

ISO 7250-1: 2008, *Basic Human Body Measurements for Technological Design – Part 1: Body Measurement Definitions and Landmarks.*

ISO 7250-2: 2010, *Basic Human Body Measurements for Technological Design – Part 2: Statistical Summaries of Body Measurements from Individual ISO Populations.* www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1311

ISO 7250-3: 2013, *Basic Human Body Measurements for Technological Design – Part 3: Worldwide and Regional Design Ranges for Use in ISO Products Standards*.

ISO 9241-11: 1998, *Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs) – Part 11: Guidance on Usability*.

ISO 20282-1: 2006, *Ease of Operation of Everyday Products – Part 1: Context of Use and User characteristics*.

ISO 21542: 2011, *Building Construction – Accessibility and Usability of the Built Environment*.

ISO/TS 20282-2: 2013, *Usability of Consumer Products and Products for Public Use – Part 2: Summative Test Method*.

Jordan, Patrick W.: 1999, Inclusive design, in: *Human Factors in Product Design – Current Practice and Future Trends*, (Green, W. S. and Jordan, P. W., eds.), pp. 171: 181, CRC Press, Taylor & Francis Group, Boca Raton, London, New York.

Keates, Simeon: 2009, Motor impairments and universal access, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 5-1: 5-14, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

Keates, Simeon and **Clarkson, John:** 2004, *Countering Design Exclusion: An Introduction to Inclusive Design*, Springer-Verlag London Limited.

Ketcham, Caroline J. and **Stelmach, George E.:** 2004, Movement control in the older adult, in: *Technology for Adaptive Aging*, (Pew, Richard W. and Van Hemel, Susan B., eds.), pp. 64: 92, National Research Council of National Academies, Washington (DC). Available at: www.ncbi.nlm.nih.gov/books/NBK97342/

kickstart.org Accessed June 23, 2013

King, Robert C., Stansfield, William D. and **Mulligan, Pamela K.:** 2006, *A Dictionary of Genetics*, 7th edition, Oxford University Press.

Kinzel, Erin and **Jacko, Julie A.:** 2009, Sensory impairments, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 6-1: 6-14, CRC Press, Taylor & Francis Group, Boca Raton/London/New York.

Knox, David and **Schacht, Caroline:** 2011, *Choices in Relationships: An Introduction to Marriage and the Family*, 11th edition, Wadsworth, Cengage Learning.

Kurniawan, Sri: 2009, Age-related differences in the interface design process, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 8-1: 8-12, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

Larson, H. and **Gips, J.:** 2003, A web browser for people with quadriplegia, in: *Universal Access in HCI: Inclusive Design in the Information Society (Volume 4 of the Proceedings of HCI International 2003)*, (Stephanidis, Constantine, ed.), pp. 226: 230, Mahwah, NJ, Lawrence Erlbaum Associates.

Lawrence, Eleanor: 2005, *Henderson's Dictionary of Biology*, 13th edition, Pearson, Prentice Hall.

Lawton, M. Powell: 1990, An environmental psychologist ages, in: *Environment and Behavior Studies, Emergence of Intellectual Traditions*, (Altman, Irwin and Christensen, Kathleen, eds.), vol. 11, pp. 339: 363, Springer, Boston, MA.

lboro.ac.uk/study/postgraduate/masters-degrees/a-z/human-factors-inclusive-design/

Lewis, Clayton: 2009, Cognitive disabilities, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 7-1: 7-12, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

Lewis, Helen; Gertsakis, John; Grant, Tim; Morelli, Nicola and **Sweatman, Andrew:** 2001, *Design + Environment – A Global Guide to Designing Greener Goods*, Greenleaf Publishing Limited, Uk.

lifestraw.com/products/lifestraw-go Accessed June 18, 2020

Lindauer, Martin S.: 2003, *Aging, Creativity, and Art: A Positive Perspective on Late-Life Development*, Springer Science+Business Media, LLC, New York.

lindstromtools.us

Lobo, Ingrid and **Shaw, Kenna:** 2008, Phenotypic range of gene expression: Environmental influence, in: *Nature Education* 1(1):12. Available at: www.nature.com/scitable/topicpage/phenotypic-range-of-gene-expression-environmental-influence-581

Mace, Ronald L.: 1991, Accessible for all: Universal design, in: *Interiors & Sources*, 8, pp. 28: 31.

Margolin, Victor and **Margolin, Sylvia:** 2002, A 'Social model' of design: Issues of practice and research, in: *Design Issues*, vol. 18, no. 4, pp. 24: 30, autumn 2002.

Marcus, Aaron and **Rau, Pei-Luen Patrick:** 2009, International and intercultural user interfaces, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 9-1: 9-11, CRC Press, Taylor & Francis Group, Boca Raton/London/New York.

Marshall, Tim: 2008, Discipline, in *Design Dictionary: Perspectives on Design Terminology,* (Erlhoff, Michael and Marshall, Tim, eds.), pp. 132: 137, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Marshall, Tim: 2008, Not-for-profit, in: *Design Dictionary: Perspectives on Design Terminology*, (Erlhoff, Michael and Marshall, Tim, eds.), p. 273, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Marshall, Tim: 2008, Wicked problems, in: *Design Dictionary: Perspectives on Design Terminology,* (Erlhoff, Michael and Marshall, Tim, eds.), p. 447, Birkhäuser Verlage AG, Basel/Boston/Berlin.

Martijn van Mensvoort: *Finger Length Around the World*! Available at: www.handresearch.com/diagnostics/finger-length-around-the-world-international-populations.htm Accessed May 11, 2017

Marshak, Laura E.; Dandeneau, Claire J.; Prezant, Fran P. and **L'Amoreaux, Nadene A.:** 2010, *The School Counselor's Guide to Helping Students with Disabilities*, Jossey-Bass, John Wiley & Sons.

Maslow, Abraham H.: 1943, A theory of human motivation, in: *Psychological Review* 50(4), 370: 396. Available at: psychclassics.yorku.ca/Maslow/motivation.htm Accessed June 23, 2013

Max-Neef, Manfred A.; Elizalde, Antonio and **Hopenhayn, Martin**: 1991, *Human Scale Development: Conception, Application and Further Reflections*, The Apex Press, New York/ London.

McDermott, Catherine: 2007, *Design – The Key Concepts*, 1st edition, Routledge.

Merriam Webster: *Cline.* Available at: www.merriam-webster.com/dictionary/cline Accessed April 18, 2017

Merriam Webster: *Experience.* Available at: www.merriam-webster.com/dictionary/experience Accessed April 18, 2017

Merriam Webster: *Skill.* Available at: www.merriam-webster.com/dictionary/skill Accessed April 18, 2017

Moheet.com: 2015, *Licensed Vehicles in Egypt Amounted to 8.4 Million Vehicles until June 2015*, November 3. Available at: www.moheet.com/2015/11/03/2343130/%D8%A7%D9%84%D8%B3%D9%8A%D8%A7%D8%B1%D8%A7%D8%AA-%D8%A7%D9%84%D9%85%D8%B1%D8%AE%D8%B5%D8%A9-%D9%81%D9%8A-%D9%85%D8%B5%D8%B1-%D8%A8%D9%84%D8%BA%D8%AA-8-4-%D9%85%D9%84%D9%8A%D9%88%D9%86-%D8%B3%D9%8A.html#.WD0RNI-cFPZ Accessed November 29, 2016

moladi.net/distribution_export.htm Accessed June 23, 2013

moladi.net/index.htm Accessed June 23, 2013

moladi.net/technology_advantages.htm Accessed June 23, 2013

Moore, Brian C. J.: 1982, *An Introduction to the Psychology of Hearing*, 2nd edition, Academic Press, New York.

Morelli, Nicola: 2007, Social innovation and new industrial contexts: Can designers "industrialize" socially responsible solutions? In: *Design Issues*, vol. 23, no. 4, pp. 3: 21, autumn, the MIT Press.

Myatt, Elizabeth D.; Essa, Irfan and **Rogers, Wendy:** 2000, Increasing the opportunities for ageing in place, in: *The Proceedings of the ACM Conference on Universal Usability (CUU 2000)*, November 16& 17, Arlington, Virginia, pp. 65: 71, ACM Press, New York. Available at:
www.cc.gatech.edu/fce/ahri/publications/agingInPlace-cuu2000.pdf

Myerson, Jeremy: 2007, A growing movement, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 23: 31, Gower Publishing Limited.

Mynott, C. et al: 1994, *Successful Product Development: Management Case Studies*, M90s Publications, London.

National academy on an aging society: 1999, *Hearing Loss – A Growing Problem that Affects Quality of Life*, no. 2, December. Available at:
www.agingsociety.org/agingsociety/pdf/hearing.pdf

nchpad.org/Directories/Organizations/2558/Center~for~Universal~Design~-~North~Carolina~State~University Accessed March 23, 2018

NCSU Libraries: *Ronald L. Mace Papers 1974-1998*, September 2005. Available at:
www.lib.ncsu.edu/findingaids/mc00260/summary Accessed March 23, 2018

Nelson, Todd D. (ed.): 2004, *Ageism: Stereotyping and Prejudice Against Older Persons*, A Bradford Book.

Newell, Alan F.; Carmichael, Alex; Gregor, Peter and **Alm, Norman:** 2003, Information technology for cognitive support, in: *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*, (Jacko, Julie A. and Sears, Andrew, eds.), pp. 464: 481, Lawrence Erlbaum Associates Inc., Hillsdale, NJ, USA.

Newell, Alan and **Monk, Andrew:** 2007, Involving older people in design, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design*, (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 111: 130, Gower Publishing Limited.

NIDCD: 2014, *Age-Related Hearing Loss*. Available at:
www.nidcd.nih.gov/health/hearing/Pages/Age-Related-Hearing-Loss.aspx Accessed February 15, 2015

NINDS: *NINDS Dyslexia Information Page*. Available at:
www.ninds.nih.gov/Disorders/All-Disorders/Dyslexia-Information-Page Accessed February 15, 2017

Ogden, Cynthia L. et al: 2004, *Mean Body Weight, Height, and Body Mass Index, United States 1960: 2002,* Advance Data from Vital and Health Statistics, no. 347, October 27, Hyattsville, Maryland: National Center for Health Statistics.

Ohio State University Extension: *When Does Someone Attain Old Age?* Senior Series. Available at:
http://ohioline.osu.edu/ss-fact/0101.html Accessed February 15, 2015

one.laptop.org/about/mission Accessed June 23, 2013

one.laptop.org/map Accessed June 23, 2013

one.laptop.org/stories Accessed June 23, 2013

Ossorio, Pilar and **Duster, Troy:** 2005, Race and genetics: Controversies in biomedical, behavioral, and forensic sciences, in: *American Psychologist*, vol. 60 (1), Jan 2005, pp. 115: 128. Available at: http://psych.colorado.edu/~willcutt/pdfs/Ossorio_2005.pdf

Oxford dictionary: *Ableism*. Available at: www.oxforddictionaries.com/definition/english/ableism Accessed February 15, 2015

Oxford dictionary: *Old Age*. Available at: www.oxforddictionaries.com/definition/english/old-age?q=old+age Accessed February 15, 2015

oxo.com

Papanek, Victor: 1971, *Design for the Real World: Human Ecology and Social Change*, Pantheon Books, New York.

paulpolak.com/design Accessed October 25, 2020

paulpolak.com/spring-health/ Accessed October 25, 2020

paulpolak.com/the-future-corporation/ Accessed October 25, 2020

Persson, Hans; Ahman, Henrik; Yngling, Alexander Arveiand and **Gulliksen, Jan:** 2014, Universal design, inclusive design, accessible design, design for all: Different concepts – one goal? On the concept of accessibility – historical, methodological and philosophical aspects, in: *Journal of Universal Access in the Information Society (UAIS)*, vol. 14, no. 4, p. 505: 526, Springer Verlag, Berlin and Heidelberg.

Pirkl, James J.: 1991, Transgenerational design: A design strategy whose time has arrived, in: *Design Management Journal*, 2 (4), pp. 55: 60, Design Management Institute Press, Boston.

Pirkl, James J.: 1993, *Transgenerational Design: Products for an Ageing Population*, New York, NY: Van Nostrand Reinhold.

Pirkl, James J. and **Babic, Anne L.:** 1988, *Guidelines and Strategies for Designing Transgenerational Products: An Instructors Manual*, Acton, MA, Copley Publishing Group.

Posner, Richard A.: 1997, *Aging and Old Age*, The University of Chicago Press, Chicago.

Prahalad, Coimbatore Krishnarao and **Hart, Stuart L.:** 2002, *The Fortune at the Bottom of the Pyramid*, strategy+business magazine, issue 26, 1st quarter, e-Doc, Booz Allen Hamilton Inc.

Preiser, Wolfgang F. E. and **Ostroff, Elaine:** 2001, *Universal Design Handbook*, McGraw-Hill, New York.

Preiser, Wolfgang F. E. and **Smith, Korydon H.:** 2011, *Universal Design Handbook*, 2nd edition, McGraw-Hill, New York.

projects.ncsu.edu/ncsu/design/cud/ Accessed March 23, 2018

pseau.org/outils/biblio/resume.php?d=2942 Accessed October 28, 2020

qdrum.co.za Accessed June 23, 2013

qdrum.co.za/about-q-drum Accessed June 23, 2013

Quadagno, Jill S.: 2017, *Aging and the Life Course: An Introduction to Social Gerontology*, 7th edition, kindle edition, McGraw-Hill Education.

Ralston, Amy and **Shaw, Kenna:** 2008, Environment controls gene expression: Sex determination and the onset of genetic disorders, in: *Nature Education* 1(1):203. Available at: www.nature.com/scitable/topicpage/environment-controls-gene-expression-sex-determination-and-982

Rauch, Jonathan: 1995, Short guys finish last, in: *The Economist*, December 23. Available at: www.jonathanrauch.com/jrauch_articles/height_discrimination_short_guys_finish_last/index.html

rca.ac.uk/research-innovation/helen-hamlyn-centre/ Accessed March 23, 2018

rca.ac.uk/research-innovation/helen-hamlyn-centre/knowledge_exchange/include-conferences/ Accessed March 23, 2018

Reece, Jane B.; Urry, Lisa A.; Cain, Michael L.; Wasserman, Steven A.; Minorsky, Peter V. and **Jackson, Robert B.:** 2011, *Campbell Biology*, 9th edition, Benjamin Cummings.

Reilly, Jill: 2012, Too fat to fly: Sick American woman dies in Hungary after 'airline kicks her off three New York flights because she was too obese', in: *The Daily Mail*, 18:27 GMT, 26 November 2012. Available at: www.dailymail.co.uk/news/article-2238590/Sick-US-woman-died-Hungary-airline-booted-New-York-flights-fat-fly.html

rightleftrightwrong.com/statistics.html Accessed November 11, 2014

Rothschild, J.: 1999, *Design and Feminism – Re-envisioning Spaces, Places and Everyday Things*, New Brunswick, NJ: Rutgers University Press.

Salah, Hager: 2013, Housing only for pashas, in: *Al-Ahram Newspaper*, no. 46110, Egypt, p. 6, March 5. Available at:
www.ahram.org.eg/NewsQ/134869.aspx

Schieber, Frank: 2003, Human factors and aging: Identifying and compensating for age-related deficits in sensory and cognitive function, in: *Impact of Technology on Successful Aging*, (Charness, Nail and Schaie, K.Warner, eds.), pp. 42: 84, Springer Publishing Company, Inc., New York.

Sears, A.; Lin, M.; Jacko, J. and **Xiao, Y.:** 2003, When computers fade: Pervasive computing and situationally induced impairments and disabilities, in: *Human-Computer Interaction: Theory and Practice (Part II) (Volume 2 of the Proceedings of HCI International 2003)*, (Stephanidis, C. and Jacko, J., eds.), pp. 1298: 1302, Mahwah, NJ: Lawrence Erlbaum Associates.

Shah, Anup: 2013, Poverty facts and stats, in: *Global Issues – Social, Political, Economic and Environmental Issues That Affect Us All*. Available at: globalissues.org/article/26/poverty-facts-and-stats#fact7 Accessed March 18, 2015

shidhulai.org/ Accessed June 23, 2013

shop.un.org/

Smith, Cynthia E.: 2007, *Design for the Other 90%*, Cooper-Hewitt, National Design Museum, Smithsonian Institution.

Smith, Cynthia E.: 2011, *Design with the Other 90%: Cities*, Cooper-Hewitt, National Design Museum, Smithsonian Institution.

social.yourstory.in/2013/01/spring-health-how-design-thinking-brought-clean-water-to-rural-india/ Accessed October 22, 2013

Spahn, J. Jeffrey: 2003, A new capitalist manifesto? Re-imagining business in the 21st century, in: *Virtual Strategist*, issue 5, spring.

Spector, A.: 1982, Aging of the lens and cataract formation, in: *Aging and Human Visual Functions* (Sekuler, R., Kline, D. and Dismukes, K., eds.), pp. 27: 43, New York: Alan R. Liss.

Spector, Tim: 2012, *Identically Different: Why You Can Change Your Genes*, Weidenfeld & Nicolson.

St. Luke's Cataract & Laser Institute: *Cataract*. Available at: www.stlukeseye.com/conditions/cataracts.html Accessed February 15, 2015

St. Luke's Cataract & Laser Institute: *Presbyopia*. Available at: www.stlukeseye.com/Conditions/presbyopia.html Accessed February 15, 2015

stabilo.com/com/stories/easy-start/ Accessed March 23, 2018

Statista: 2017, *Anzahl der Ausländer in Deutschland nach Herkunftsland in den Jahren 2016 und 2017*. Available at: https://de.statista.com/statistik/daten/studie/1221/umfrage/anzahl-der-auslaender-in-deutschland-nach-herkunftsland/ Accessed March 23, 2018

Statista: *Worldwide Automobile Production from 2000 to 2015 (in Million Vehicles)*. Available at: https://www.statista.com/statistics/262747/worldwide-automobile-production-since-2000/ Accessed November 29, 2016

statista.com

statisticbrain.com/left-handed-statistics/ Accessed November 11, 2014

StatLine: 2014, *Reported Height, 20 Years or Older*, Central Bureau of Statistics, July 3. Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=81177eng&D1=14-25&D2=0-12,26-38&D3=0&D4=l&LA=EN&HDR=T&STB=G1,G2,G3&VW=T Accessed November 11, 2014

StatLine: 2014, *Reported Weight, 20 Years or Older*, Central Bureau of Statistics, July 3. Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=81177eng&D1=26-38&D2=0-12,26-38&D3=0&D4=l&LA=EN&HDR=T&STB=G1,G2,G3&VW=T Accessed November 11, 2014

StatLine: 2014, *Under- and Overweight, 4 Years or Older*, Central Bureau of Statistics, July 3. Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=81177eng&D1=39-43&D2=0-12,26-38&D3=0&D4=l&LA=EN&HDR=T&STB=G1,G2,G3&VW=T Accessed November 11, 2014

statpac.com/surveys/research-methods.htm Accessed March 23, 2018

steadyhealth.com/articles/difference-between-male-and-female-structures-mental-and-physical Accessed March 1, 2014

Steger, Manfred B.: 2003, *Globalization: A Very Short Introduction*, Oxford University Press, Oxford.

Stein, L. K.: 1988, Hearing impairment, in: *Handbook of Developmental and Physical Disabilities*, (V. B. Van Hassek, ed.), pp. 271: 294, Pergamon Press, New York.

Stephanidis, Constantine: 2009, *The Universal Access Handbook*, CRC Press, Taylor & Francis Group, Boca Raton/London/New York.

Stephanidis, Constantine: 2009, Universal access and design for all in the evolving information society, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 1-1: 1-11, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

stinasolstrale.wordpress.com/2012/02/16/the-watercone-making-clean-drinking-water-avalible-to-everybody/

Story, Molly Follette; Mueller, James L. and **Mace, Ronald L.:** 1998, *The Universal Design File: Designing for People of All Ages and Abilities*, NC State University, The Center for Universal Design.

Stoukides, J.; Holzer, C.; Ritzau, J. and **Burbank, P.:** 2006, Health issues of frail older adults, in: *Vulnerable Older Adults – Health Care Needs and Interventions*, (Burbank, Patricia M., ed.), pp. 3: 24, Spring Publishing Company, New York.

Stummvoll, G. and **Davey, Caroline L.:** 2003, *Environmental Crime Prevention in Vienna: A Feminist Approach*, Design Against Crime Case Study funded by the European Commission's Hippokrates (2002) programme project 'A European Resource Directory for the Design of Secure Urban Environments', The University of Salford.

Supple, Sarah: 2005, Disability – Special issue, in: *The Psychologist*, vol. 18, no. 7, pp. 418: 429. Available at: https://thepsychologist.bps.org.uk/volume-18/edition-7/disability-special-issue and https://thepsychologist.bps.org.uk/getfile/2368

Szlyk, J.P.; Seiple, W. and **Viana, M.:** 1995, Relative effects of age and compromised vision on driving performance, in: *Human Factors 37* (2), pp. 430: 436.

thomasberry.org Accessed October 29, 2020

Tonkinwise, Cameron: 2008, Sustainability, in: *Design Dictionary: Perspectives on Design Terminology,* (Erlhoff, Michael and Marshall, Tim, eds.), pp. 380: 386, Birkhäuser Verlage AG, Basel/Boston/Berlin.

toyota.com/sienna/ebrochure/ Accessed March 23, 2018

toyotamobility.com/mobility_solutions.html Accessed March 23, 2018

toyotavacaville.com/blog/what-is-toyota-sienna-auto-access-seat/ Accessed March 23, 2018

Thackara, John: 2007, Foreword, in: *Designers, Visionaries and Other Stories – A Collection of Sustainable Design Essays*, (Chapman, Jonathan and Gant, Nicholas, eds.), pp. xvi: xviii, Earthscan, London.

theindexproject.org

theindexproject.org/about

Turner, John S., JR.: 1990, The ear and auditory system, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 126, Emory University School of Medicine, Atlanta, Georgia. Available at: www.ncbi.nlm.nih.gov/books/NBK231/

Turner, John S., JR. and **Per-Lee, John H.:** 1990, Auditory dysfunction: Hearing loss, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 120, Emory University School of Medicine, Atlanta, Georgia. Available at: www.ncbi.nlm.nih.gov/books/NBK225/

UN: 2006, *Convention on the Rights of Persons with Disabilities*, effective on 3 May 2008.

UN: 2007, *The Millennium Development Goals Report 2007*, Department of Economic and Social Affairs, New York. Available at: www.un.org/millenniumgoals/pdf/mdg2007.pdf

UN: 2017, *International Migration Report 2017*, Department of Economic and Social Affairs – Population Division, December. Available at: www.un.org/en/development/desa/population/migration/publications/migrationreport/docs/MigrationReport2017.pdf

UN: 2017, *Profiles of Ageing 2017*, Department of Economic and Social Affairs – Population Division, December. Available at: https://population.un.org/ProfilesOfAgeing2017/index.html

UN: 2017, *World Population Ageing 2017 – Highlights*, Department of Economic and Social Affairs – Population Division, December. Available at: www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf

UN: 2017, *World Population Ageing 2017 – Report*, Department of Economic and Social Affairs – Population Division, December. Available at: www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Report.pdf

un.org/en/development/desa/population/migration/index.shtml Accessed March 23, 2018

UNDP: 2006, *Human Development Report 2006 – Beyond Scarcity: Power, Poverty and the Global Water Crisis*, Palgrave Macmillan, New York.

UNDP: 2007, *Human Development Report 2007/2008 – Fighting Climate Change: Human Solidarity in a Divided World*, Palgrave Macmillan, New York.

UNDP: 2010, *Human Development Report 2010 – The Real Wealth of Nations: Pathways to Human Development*, Palgrave Macmillan, New York.

UNDP: 2011, *Human Development Report 2011 – Sustainability and Equity: A Better Future for All*, Palgrave Macmillan, New York.

undp.org/content/undp/en/home/

UNESCO: 2009, *UNESCO World Report – Investing in Cultural Diversity and Intercultural Dialogue.*

UNESCO: 2009, *UNESCO World Report – Investing in Cultural Diversity and Intercultural Dialogue*, executive summary.

UNICEF and **WHO:** 2009, *Diarrhoea: Why Children are Still Dying and What Can Be Done,* ISBN 978-92-806-4462-3 (UNICEF), ISBN 978-92-4-159841-5 (NLM classification: WS 312) (WHO).

universaldesign.com/

upload.wikimedia.org/wikipedia/commons/thumb/7/7f/Toyota_Porte_02.jpg/1200px-Toyota_Porte_02.jpg Accessed June 3, 2019

USCB: 2004, *American Community Survey*. Available at: https://factfinder.census.gov/jsp/saff/SAFFInfo.jsp?_pageId=sp1_acs%20&_submenuId

Vanderheiden, Gregg C.: 2009, Accessible and usable design of information and communication technologies, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 3-1: 3-26, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

Vercruyssen, Max: 1997, Movement control and the speed of behavior, in: *Handbook of Human Factors and the Older Adult*, (Fisk, Arthur D. and Rogers, Wendy A., eds.), pp. 55: 86, Academic Press, San Diego, CA, US.

vestergaard-frandsen.com/lifestraw Accessed June 23, 2013

vestergaard-frandsen.com/lifestraw/lifestraw-family Accessed June 23, 2013

vestergaard-frandsen.com/lifestraw/lifestraw-family/features Accessed June 23, 2013

vestergaard-frandsen.com/lifestraw/lifestraw-community Accessed June 23, 2013

vestergaard-frandsen.com/lifestraw/lifestraw/features Accessed June 23, 2013

Vezzoli, Carlo and **Manzini, Ezio:** 2008, *Design for Environmental Sustainability*, Springer-Verlag, London.

virtualoffice.com.br Accessed April 17, 2018

www-edc.eng.cam.ac.uk/research/inclusivedesign/ Accessed November 19, 2018

Walker, N.; Philbin, D.A. and **Fisk, A.D.:** 1997, Age-related differences in movement control: Adjusting submovement structure to optimize performance, in: *Journal of Gerontology: Psychological Sciences* 52B (1), pp. 40: 52.

Waller, Sam and **Clarkson, John:** Framework section, in: *Inclusive Design Toolkit*. Available at: www.inclusivedesigntoolkit.com/betterdesign2/UCframework/framework.html Accessed February 15, 2015

Walker, Stuart: 2006, *Sustainable by Design: Explorations in Theory Practice,* Earthscan, London, UK.

Walpole, Sarah C. et al.: 2012, *The Weight of Nations: An Estimation of Adult Human Biomass*, BMC Public Health, vol. 12, pp. 439: 444. Available at: www.biomedcentral.com/1471-2458/12/439

watercone.com

watercone.com/pictures.html Accessed December 22, 2018

watercone.com/product.html Accessed December 22, 2018

Waterland, Robert A. and **Jirtle, Randy L.:** 2003, Transposable elements: targets for early nutritional effects on epigenetic gene regulation, in: *Molecular and Cellular Biology*, vol.23 (15), pp. 5293: 5300. Available at: www.ncbi.nlm.nih.gov/pmc/articles/PMC165709/

WB: 2007, *Arab Republic of Egypt – Poverty Assessment Update*, Report no. 39885 – EG, vol. I.

WB: 2008, *World Development Indicators 2008*, August.

WCED: 1987, *Our Common Future*, Oxford: Oxford University Press.

wdo.org/glossary/sustainability/ Accessed December 10, 2020

whirlwindwheelchair.org/ Accessed March 14, 2018

whirlwindwheelchair.org/about-us/ Accessed March 14, 2018

Whiteley, Nigel: 1993, *Design for Society*, Reaktion Books, London.

who.int/gho/en/

who.int/publications/en/

WHO: 2001, *International Classification of Functioning, Disability and Health (ICF)*, Geneva.

WHO: 2014, *Visual Impairment and Blindness*, fact sheet no. 282, August. Available at: www.who.int/mediacentre/factsheets/fs282/en/

WHO: 2015, *Dementia*, fact sheet no. 362, March. Available at: www.who.int/mediacentre/factsheets/fs362/en/

WHO: 2016, *Obesity and Overweight*, fact sheet no. 311**,** June. Available at: www.who.int/mediacentre/factsheets/fs311/en/

WHO: 2017, *Blindness and Visual Impairment*, Key facts, October 11. Available at: www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment

WHO: 2018, *Deafness and Hearing Loss*, Key facts, March 15. Available at: www.who.int/en/news-room/fact-sheets/detail/deafness-and-hearing-loss

WHO: *Chronic Rheumatic Conditions*. Available at: www.who.int/chp/topics/rheumatic/en/# Accessed February 15, 2015

WHO: *Definition of an Older or Elderly Person*. Available at: www.who.int/healthinfo/survey/ageingdefnolder/en/# Accessed February 15, 2015

WHO: *What Do We Mean by "Sex" and "Gender"?* Available at: www.who.int/gender/whatisgender/en/index.html# Accessed March 1, 2014

Wikipedia: *Ableism*. Accessed February 15, 2015

Wikipedia: *Active Suspension*. Accessed November 9, 2016

Wikipedia: *Ageing*. Accessed February 15, 2015

Wikipedia: *Allele*. Accessed March 18, 2015

Wikipedia: *Ametropia*. Accessed February 15, 2015

Wikipedia: *Anatomy*. Accessed February 15, 2015

Wikipedia: *Anthropometry*. Accessed March 18, 2015

Wikipedia: *Architecture for Humanity*. Accessed March 18, 2015

Wikipedia: *Biological System*. Accessed February 15, 2015

Wikipedia: *Cline (Biology)*. Accessed March 18, 2015

Wikipedia: *Discrimination.* Accessed March 23, 2018

Wikipedia: *Edward Enninful*. Accessed October 29, 2020

Wikipedia: *Epigenetics*. Accessed March 18, 2015

Wikipedia: *Gender Role*. Accessed February 15, 2015

Wikipedia: *Genetic Variability*. Accessed March 18, 2015

Wikipedia: *George Herbert Mead*. Accessed October 29, 2020

Wikipedia: *Height Adjustable Suspension*. Accessed November 9, 2016

Wikipedia: *Height Discrimination*. Accessed March 18, 2015

Wikipedia: *Hierarchy of Needs*. Accessed February 15, 2015

Wikipedia: *Hu Jintao*. Accessed October 29, 2020

Wikipedia: *Human Body*. Accessed February 15, 2015

Wikipedia: *Human Genetic Variation*. Accessed March 18, 2015

Wikipedia: *Human Height*. Accessed March 18, 2015

Wikipedia: *Human Weight*. Accessed March 18, 2015

Wikipedia: *Mahatma Gandhi*. Accessed October 29, 2020

Wikipedia: *Low-Floor Bus*. Accessed March 18, 2015

Wikipedia: *Lucia Zarate*. Accessed March 18, 2015

Wikipedia: *Old Age*. Accessed February 15, 2015

Wikipedia: *Paul Polak*. Accessed March 18, 2015

Wikipedia: *Phenotypic Trait*. Accessed March 18, 2015

Wikipedia: *Population*. Accessed March 18, 2015

Wikipedia: *Population Genetics*. Accessed March 18, 2015

Wikipedia: *Race (Human Classification)*. Accessed March 18, 2015

Wikipedia: *Roland Mace.* Accessed March 23, 2018

Wikipedia: *Secondary Sex Characteristics*. Accessed February 15, 2015

Wikipedia: *Sense*. Accessed February 15, 2015

Wikipedia: *Sex Differences in Humans*. Accessed February 15, 2015

Wikipedia: *Social Enterprise*. Accessed March 18, 2015

Wikipedia: *W. Ross Ashby*. Accessed October 29, 2020

Wilkinson, Richard and **Pickett, Kate**: 2009, *The Spirit Level: Why Equality is Better for Everyone*, Penguin Group.

wonderfulengineering.com/fords-age-suit-lets-you-experience-life-as-a-104-year-old-man/ Accessed November 19, 2018

World Council of Churches: 1974, *Report of Ecumenical Study Conference on Science and Technology for Human Development*, Geneva, World Council of Churches.

Wright, Jim; Gundry, Stephen and **Conroy, Ronan:** 2004, Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use, in: *Tropical Medicine and International Health*, vol. 9, no. 1, pp. 106: 117, January, Blackwell Publishing Ltd.

Wright, Sewall: 1978, *Evolution and the Genetics of Populations, vol. 4: Variability within and among Natural Population*, University of Chicago Press.

yankilee.com/wwwdesigningwithpeopleorg Accessed December 10, 2020

youtu.be/CEDF9ut7iCc Accessed November 19, 2018

youtu.be/Gb5iHzCT7Tk Accessed October 29, 2020

youtu.be/GpKwhSc4d68 Accessed November 19, 2018

youtu.be/SH9elFMSoZs Accessed August 19, 2013

youtube.com/watch?v=ezVxt7TkyeM&feature=youtu.be Accessed October 22, 2013

Zarbin, M. A.: 1998, Age-related macular degeneration: Review of pathogenesis, in: *European Journal of Ophthalmology*, 8, pp. 199: 206.

Zizza, Claire A.; Ellison, Kathy Jo and **Wernette, Catherine M.:** 2009, Total water intakes of community-living middle-old and oldest-old adults, in: *J Gerontol A Biol Sci Med Sci*, 64 A (4), pp. 481: 486. Available at: www.ncbi.nlm.nih.gov/pmc/articles/PMC2657166/

6. Appendices

6. Appendices

6.1. Appendix: Human life areas and human activities

Human life areas and human activities include (WHO: 2001, pp. 39: 42 and pp. 125: 170):

- **Learning and applying knowledge:**
- Purposeful sensory experiences: Watching, Listening, Other purposeful sensing
- Basic learning: Copying, Rehearsing, Learning to read, Learning to write, Learning to calculate, Acquiring skills
- Applying knowledge: Focusing attention, Thinking, Reading, Writing, Calculating, Solving problems, Making decisions

- **General tasks and demands:** Undertaking a single task, Undertaking multiple tasks, Carrying out a daily routine, Handling stress and other psychological demands

- **Communication:**
- Communicating – receiving: Communicating with and receiving spoken messages, nonverbal messages, formal sign language messages and written messages
- Communicating – producing: Speaking, Producing nonverbal messages, Producing formal sign language messages, Writing messages
- Conversation and use of communication devices and techniques: Conversation, Discussion, Using communication devices and techniques

- **Mobility:**
- Changing and maintaining body position: Changing basic body position, Maintaining a body position, Transferring oneself
- Carrying, moving and handling objects: Lifting and carrying objects, Moving objects with lower extremities, Fine hand use, Hand and arm use
- Walking and moving: Walking, Moving around, Moving around in different locations, Moving around using equipment

- Moving around using transportation: Using transportation, Driving, Riding animals for transportation

- **Self-care:** Washing oneself, Caring for body parts, Toileting, Dressing, Eating, Drinking, Looking after one's health

- **Domestic life:**

- Acquisition of necessities: Acquiring a place to live, Acquisition of goods and services
- Household tasks: Preparing meals, Doing housework
- Caring for household objects and assisting others: Caring for household objects, Assisting others

- **Interpersonal interactions and relationships:**

- General interpersonal interactions: Basic interpersonal interactions, Complex interpersonal interactions
- Particular interpersonal relationships: Relating with strangers, Formal relationships, Informal social relationships, Family relationships, Intimate relationships

- **Major life areas:**

- Education: Informal education, Preschool education, School education, Vocational training, Higher education
- Work and employment: Apprenticeship (work preparation); Acquiring, keeping and terminating a job; Remunerative employment; Non-remunerative employment
- Economic life: Basic economic transactions, Complex economic transactions, Economic self-sufficiency

- **Community, social and civic life:** Community life, Recreation and leisure, Religion and spirituality, Human rights, Political life and citizenship

6.2. Appendix: Environmental factors types: (WHO: 2001, p. 43, 44 and pp. 173: 207)

1. The natural physical world (natural environment and man-made changes to it): It includes animate and inanimate elements of the natural physical environment and components of that environment that have been modified by people, as well as characteristics of human populations within that environment. Briefly, it includes:

- Physical geography: Features of landforms and features of bodies of water.
- Flora and fauna (plants and animals).
- Climate: Temperature, humidity, atmospheric pressure, precipitation, wind and seasonal variations.
- Time-related changes: Day/night cycles and lunar cycles.
- Sound[1]: Sound intensity – level or volume of auditory phenomenon determined by the amount of energy being generated (loud and soft sounds), and sound quality – nature of a sound as determined by the wavelength and wave pattern of the sound and perceived as the timbre and tone, such as harshness or melodiousness, and which may provide useful information about the world (e.g. the sound of a dog barking versus a cat meowing) or distractions (e.g. background noise).
- Light (sunlight or artificial lighting): Light intensity – level or amount of energy being emitted by a source of light, and light quality – the nature of the light being provided and related colour contrasts created in the visual surroundings, and which may provide useful information about the world (e.g. visual information on the presence of stairs or a door) or distractions (e.g. too many visual images).
- Vibration: Regular or irregular to and from the motion of an object or an individual caused by a physical disturbance, such as shaking, quivering, quick jerky movements of things, buildings or people caused by small or large equipment, aircraft and explosions.
- Air quality: Characteristics of the atmosphere in open or closed areas.
- Natural phenomena: Geographic and atmospheric changes that disrupt an individual's physical environment, occurring regularly or irregularly, such as earthquakes and severe or violent weather conditions, e.g. tornadoes, hurricanes, typhoons, floods, forest fires and ice storms.
- Man-caused events: Alterations or disturbances in the natural environment, caused by humans, that may result in the disruption of people's day-to-day lives, incl. events or conditions linked to conflict and wars, such as the displacement of people; destruction of social infrastructure, homes and lands; environmental disasters; and land, water or air pollution (e.g. toxic spills).

[1] A phenomenon that is or may be heard in any volume, timbre or tone, and that may provide useful or distracting information about the world.

- Population[1]: Demographic change (changes occurring within groups of people, such as the composition and variation in the total number of individuals in an area caused by birth, death, ageing of a population and migration) and population density (number of people per unit of land area).
- Others

2. The man-made physical world (equipment, products and technology): It includes the natural or man-made products or systems of products, equipment and technology in an individual's immediate environment that are gathered, created, produced or manufactured. Briefly, it includes:

- Products or substances for personal consumption (food and drugs)
- Equipment, products and technology for personal use in daily life, such as clothes, textiles, furniture, appliances, cleaning products and tools; in addition, adapted or specially designed ones, such as prosthetic and orthotic devices, neural prostheses (e.g. functional stimulation devices that control bowels, bladder, breathing and heart rate), and environmental control units aimed at facilitating individuals' control over their indoor setting (scanners, remote control systems, voice-controlled systems, timer switches).
- Equipment, products and technology for personal indoor and outdoor mobility and transportation, such as motorized and non-motorized vehicles used for the transportation of people over the ground, water and air (e.g. buses, cars, vans, other motor-powered vehicles and animal-powered transporters); in addition, adapted or specially designed ones, such as walking devices, special cars and vans, adapted vehicles, wheelchairs, etc.
- Equipment, products and technology for communication (activities of sending and receiving information), such as optical and auditory devices, audio recorders and receivers, television and video equipment, telephone devices, sound transmission systems and face-to-face communication devices; in addition, adapted or specially designed ones, such as specialized vision devices, electro-optical devices, specialized writing devices, drawing or handwriting devices, signaling systems and special computer software and hardware, cochlear implants, hearing aids, FM auditory trainers, voice prostheses, communication boards, glasses and contact lenses.
- Equipment, products and technology for educational activities (acquisition of knowledge, expertise or skill), e.g. books, manuals, educational toys, computer hardware or software; in addition, adapted or specially designed ones, e.g. specialized computer technology.
- Equipment, products and technology for work (to facilitate work activities), e.g. machines, office equipment and tools; in addition, adapted or specially designed ones, e.g. adjustable tables, desks

[1] They are groups of people living in a given environment who share the same pattern of environmental adaptation.

and filing cabinets; remote control entry and exit of office doors; computer hardware, software, accessories and environmental control units aimed at facilitating an individual's conduct of work -related tasks and aimed at control of the work environment (e.g. scanners, remote control systems, voice-controlled systems and timer switches).

- Equipment, products and technology for cultural, recreational and sporting activities, such as toys, skis, tennis balls and musical instruments; in addition, adapted or specially designed ones, such as modified mobility devices for sports, adaptations for musical and other artistic performance.
- Products and technology for the practice of religion and spirituality, such as maypoles, headdresses, masks, crucifixes, menorahs and prayer mats; in addition, adapted or specially designed ones, such as Braille religious books, Braille tarot cards, and special protection for wheelchair wheels when entering temples.
- Buildings for private and public use and their planned, designed and constructed products and technology. Buildings, such as homes, workplaces, shops and theatres; products and technology, such as portable and stationary ramps, doors, power-assisted doors, lever door handles, level door thresholds, washroom facilities, telephones, audio loops, lifts or elevators, escalators, thermostats (for temperature regulation), dispersed accessible seating, kitchen cabinets, appliances and electronic controls, signage (in Braille or writing), size of corridors and floor surfaces.
- Products and technology of land development, such as streets, sidewalks, kerb cuts, ramps, pathways, signposting, traffic lights and street lighting.
- Others

3. Support by others: It's the practical physical or emotional support, nurturing, protection, assistance and relationships provided by people[1] or animals (domesticated animals) to other persons in aspects of their daily activities.

4. Services, systems and policies:

- Services that provide benefits, structured programmes and operations, in various sectors of society, designed to meet the needs of individuals. Services may be public, private or voluntary, and may be established at a local, community, regional, state, provincial, national or international level by individuals, associations, organizations, agencies or governments. The goods provided by these services may be general or adapted and specially designed.

---

[1] They are people involved in different relationships and roles in an individual's life, such as immediate family, extended family, friends, acquaintances, peers colleagues, neighbours, community members, people in positions of authority, people in subordinate positions, personal care providers and personal assistants, strangers, health professionals and health-related professionals.

- Systems that are administrative control and organizational mechanisms, and are established by governments at the local, regional, national and international levels, or by other recognized authorities. These systems are designed to organize, control and monitor the services.
- Policies constituted by rules, regulations, conventions and standards that are established by governments at the local, regional, national and international levels, or by other recognized authorities. Policies govern and regulate the systems that organize, control and monitor services that provide benefits, structured programmes and operations in various sectors of society.

  This factor includes services, systems and policies for the production of consumer goods; services, systems and policies of architecture and construction, open space planning, housing, utilities, communication, transportation, civil protection, media, labour and employment, social security, general social support, health, and education and training; and legal, associations and organizational, economic, political services, systems and policies. See examples in (WHO: 2001, pp. 192: 207).

5. External attitudes: Attitudes are the observable consequences of ideologies (ideas and ideals) justifying a set of beliefs, values, morals, laws and norms, and their related customs (customary practices and social behaviours). Ideologies are the driving forces behind attitudes. These attitudes influence the individual behaviour and social life at all levels, from interpersonal relationships and community associations to political, economic and legal structures; e.g. individual[1] or societal[2] attitudes about a person's trustworthiness and value as a human being may motivate positive, honorific practices or negative and discriminatory practices toward a person (e.g. stigmatizing, stereotyping[3], marginalizing or neglecting a person). The external attitudes are those of people external to the person whose situation is being described.

[1] Individual attitudes: General or specific opinions and beliefs of an individual about a person or about other matters (e.g. social, political and economic issues), that influence the behaviour and actions of that individual.

[2] Societal attitudes: General or specific opinions and beliefs generally held by people of a group about other individuals or about other social, political and economic issues, that influence the behaviour and actions of those people.

[3] 'Stereotypes are a composite of ideas and beliefs attributed to people as a group or a social category. They may incorporate some characteristics or attributes that accurately describe some people who belong to the group, but they always fail to capture the diverse qualities of all the individuals in the group. Some older people, for example, may be rigid in thought, but many other are open-minded and interested in exploring new ideas.' (Quadango, J.: 2017, p. 11)

6.3. Appendix: Human body systems

6.3.1. The visual system:

It's a sensory nervous system, responsible for processing the perceived visual information. It consists of the eyes, neural pathways and parts of the brain involved in visual perception. They are transducers from the physical world to the realm of the mind where we interpret the information, creating our perception of the world around us.

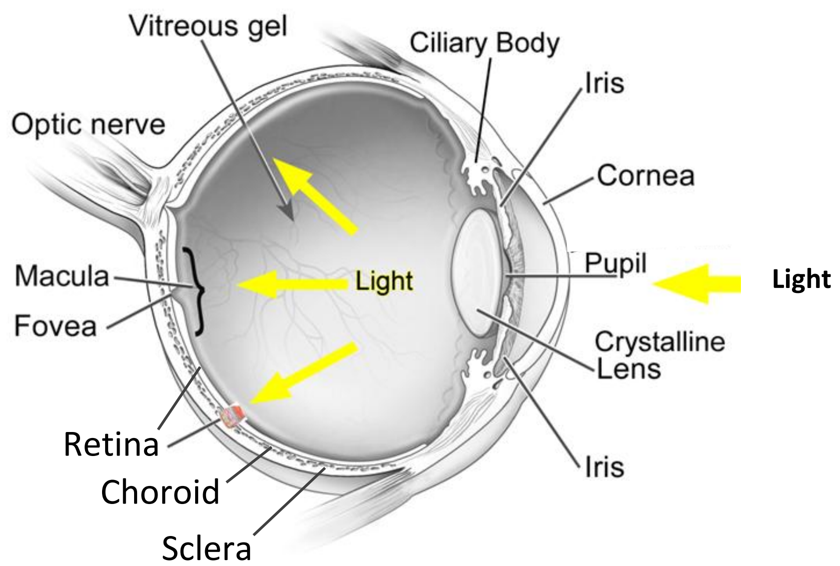


Fig. 6.1: The structure of the eye
(Vera-Díaz, F.: 2012, p. 120)

1. **The visual system parts:** The visual system consists of the following parts (Kinzel, E.: 2009, p. 6-2, 6-3)[1]:

- **The eye:** It includes – fig. 6.1:

- **The Outer Eye:** It's the outer surface of the eye and is made up of the cornea and the sclera. The cornea is a small transparent area of tissue. It has 3 main layers: the epithelium, the stroma and the endothelium. The stroma (90% of the cornea) is composed largely of collagen, which gives it a crystalline structure. The function of the epithelium and endothelium, maintaining the proper hydration balance of the stroma, is vital to maintaining corneal structure and ensuring its transparency. The sclera is the fibrous, outer coating of the eye, which appears dense and white. It serves as the protective shell of the eye, from the cornea in the front of the eye to the outer sheath of the optic nerve in the back of the eye. The extraocular muscles controlling the eye's movement, also insert into the sclera.

[1] For more information, see Oyster, Clyde W.: 1999, *The Human Eye: Structure and Function*.

- **The uveal tract**: It's composed of the iris, ciliary body, and choroid. This is the main vascular layer of the eye, which provides most of the nourishment to the eye and is protected by the sclera and the cornea. The iris, which is the most visible portion of the eye, contains a layer of muscles, arranged in a circular pattern, which contracts and dilates to regulate the amount of light allowed into the eye. The empty circular area in the void of the iridial muscles is the pupil, which usually appears black when the inner eye isn't illuminated by a flash of light. On the anterior side of this muscle is a layer of pigmented fibrovascular tissue, which appears as the coloured part of the eye. Just in front of the entire iris is a chamber, which contains more aqueous fluid. The ciliary body, which surrounds the lens, just posterior to the iris, contains muscles that attach to the lens and are responsible for shaping the lens to focus light on the retina. The lens is an avascular and almost completely transparent structure. Its main function is the refraction of light, to ensure that visual stimuli fall on the retina[1]. Also, the ciliary body provides the production of the aqueous humor providing most of the nutrients for the lens and the cornea, as well as washing away foreign debris. The choroid is the layer between the retina and the sclera and nourishes the outer portion of the retina and also serves as a dark unreflective layer to prevent light from reflecting around inside the eye.
- **The Inner Eye (retina)**: It's a sheet of neural tissue lining the inner side of the posterior wall of the eye, and is semitransparent and multilayered. It contains photoreceptor cells[2], which respond to photons of light and generate chemo-electric responses that create neural signals. In the centre of the posterior retina is the macula, which contains more ganglion cells (neurons) than the rest of the retina. In the centre of the macula is the fovea, which appears as a small dent in the centre of the retina. The foveola is the most central portion of the fovea. This retinal region provides individuals with the ability to make fine visual discriminations. The signals from the photoreceptors undergo complex processing by other neurons of the retina. The retinal output takes the form of action potentials in retinal ganglion cells whose axons form the optic nerve. Several important features of visual perception can be traced to this retinal encoding and processing of light.

▪ **The Optic Nerve:** It's responsible for transmitting visual information to the brain. It's estimated to contain 1.2 million nerve fibers, significantly less than the roughly 130 million receptors in the retina. This implies that substantial preprocessing takes place in the retina before the signals are sent to the

[1] The lens is responsible for focusing light coming into the eye onto the retina to produce clear and sharp images; when the lens of the eye becomes clouded, the eye is no longer able to adequately process light coming into the eye (Kurniawan, S.: 2009, p. 8-3). This loss of transparency appears to be particularly pronounced at short wavelengths (Said, F.: 1959); it means that less violet light enters or can reach the retina, making it harder to see colours like blue, green and violet compared with reds, oranges and yellows (AgeLight LLC: 2001).

[2] The typical human retina contains 2 kinds of light cells: rod cells and cone cells (Masland, R.: 2001).

brain through the optic nerve – fig. 6.2. Damage to the optic nerve can cause irreversible blindness since the fibers of the mammalian central nervous system are incapable of regeneration.

- **Other neural parts:** The optic nerves from both eyes meet and cross at the optic chiasm. The information from both eyes is combined at the optic chiasm and split according to the visual field. Each half of the visual field is processed in the opposite side of the brain. This split visual information feeds into the Lateral Geniculate Nucleus (LGN), which is the location of the primary processing of the visual information, through the optic tract. It has been shown that the LGN introduces relaying efficiencies by canceling out redundant information from the retina. The LGN acts as the mediator between the optic tract and the visual cortex, sending projections to the visual cortex and receiving feedback. The visual cortex lies at the rear of the brain. It's the largest system in the human brain and is responsible for higher-level processing of the visual image – fig. 6.2.

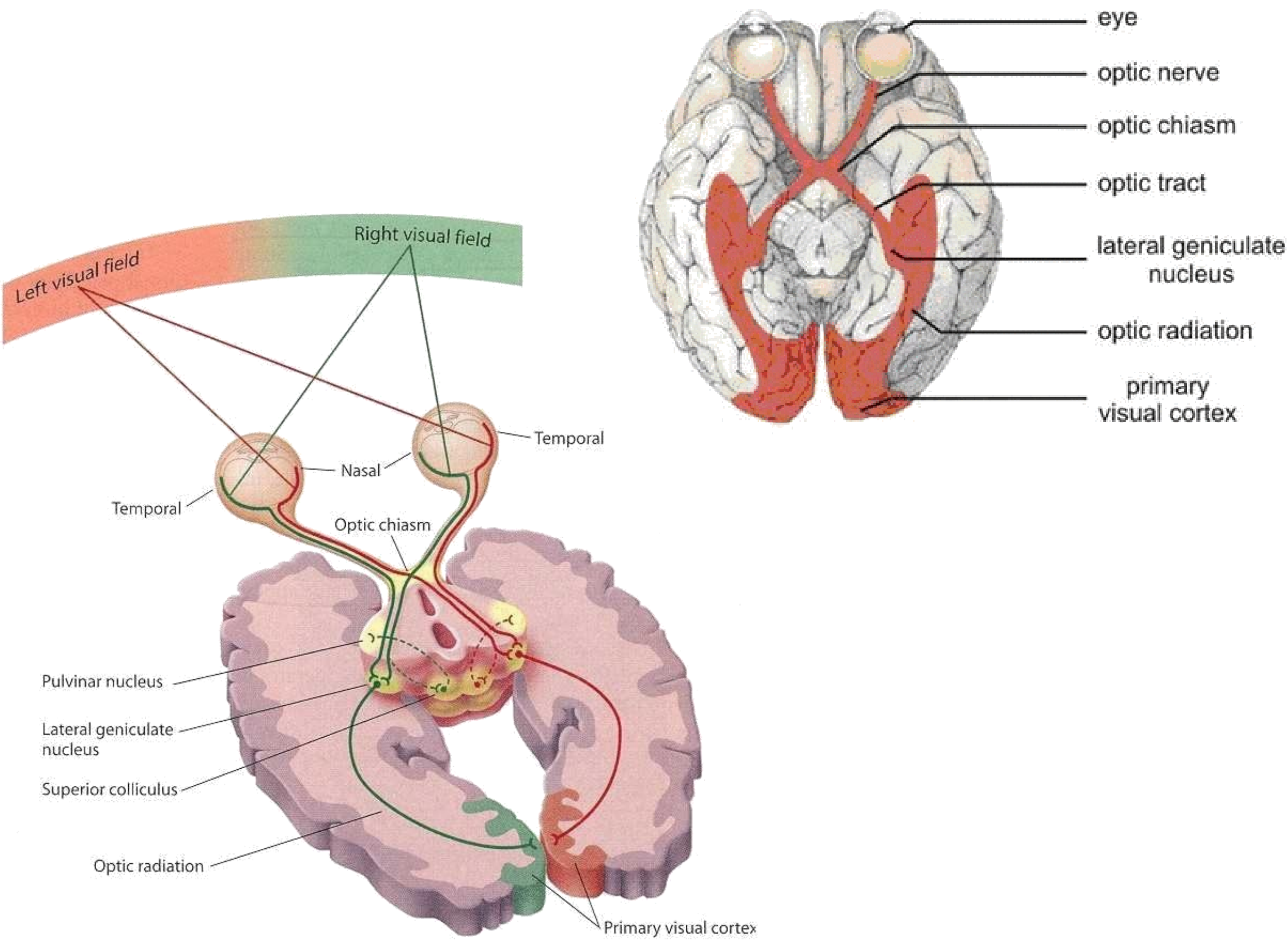


Fig. 6.2: The human visual system includes the eyes, the connecting pathways through to the visual cortex and other parts of the brain. (jjkvc.org/#!visual-system/c1hdj)

2. **Aspects of sight:** Evaluating the performance of an individual's visual system – the function of sight – is through evaluating many visual aspects or sub-functions which express the performance level of the visual system structures singly and collectively. Generally, those aspects are outlined in:

- **Visual acuity:** It 'refers to the smallest object or feature distinguishable by the eye at a particular distance' (Kinzel, E.: 2009, p. 6-3), or it's 'a measure of the visual system's ability to resolve fine spatial detail' (Schieber, F.: 2003, p. 44). It represents the acuteness or clearness of vision. It's a parameter that is frequently used to assess overall vision. The presence of excellent visual acuity means 'that the ocular media[1] are clear, the image is clearly focused on the retina, the afferent visual pathway is functioning, and the visual cortex has appropriately interpreted signals received' (Levenson, J.: 1990, Visual acuity). A deficiency in the visual acuity can be attributed to several causes such as errors in how the light is refracted in the eyeball[2] (due to, e.g. aberrations in the shape of the eyeball and/or the shape of the cornea and lack of flexibility in the crystalline lens of the eye), deterioration of the retina (loss of photoreceptor and ganglion cell – as a result of retinal disorders) and/or diminished retinal illumination (due to opacities of the ocular media, e.g. decline of transparency of the eye crystalline lens) (Levenson, J.: 1990, Visual acuity change). Since visual acuity is a general measure of the ability of the eye to distinguish objects from a particular distance, many factors may contribute to this measurement; a deficiency in contrast sensitivity and visual field for example may affect the overall ability of the eye to distinguish an object (Kinzel, E.: 2009, p. 6-4). For a general lack in visual acuity, high contrast as well as increasing the size of the objects or text can be helpful for users over a variety of impairments (ibid.).

- **Visual field:** 'The field of vision is that portion of space in which objects are visible at the same moment during steady fixation of gaze in one direction. The monocular visual field consists of central vision, which includes the inner 30 degrees of vision and central fixation, and the peripheral visual

[1] Ocular media are the normally transparent structures of the eye including the cornea, crystalline lens and vitreous (Levenson, J.: 1990, Visual acuity change).

[2] A frequent cause of low visual acuity is a refractive error (ametropia) or errors in how the light is refracted in the eyeball – an error in the focusing of light by the eye; nearsightedness (myopia), farsightedness (hyperopia) and astigmatism are types of ametropia that may happen to anybody whatever his age (Levenson, J.: 1990, Visual acuity change and Wikipedia: ametropia). Causes of these types include aberrations in the shape of the eyeball and/or the shape of the cornea and they can mostly be corrected by optical means such as eyeglasses or contact lenses or by laser surgery (Wikipedia: ametropia). Another type of ametropia is presbyopia; it's an age-related disorder where the eyes exhibit a progressively diminished ability to focus on objects or detail at close distances (Kurniawan, S.: 2009, p. 8-3 and Levenson, J.: 1990, Visual acuity change); it's caused by the gradual lack of flexibility in the crystalline lens of the eye due to the natural aging process (St. Luke's Cataract & Laser Institute: Presbyopia and Schieber, F.: 2003, p. 45). Despite its symptoms, presbyopia isn't related to nearsightedness, which is due to an abnormality in the shape of the eye (Kurniawan, S.: 2009, p. 8-3).

field[1], which extends 100 degrees laterally, 60 degrees medially, 60 degrees upward, and 75 degrees downward. .... Visual acuity increases from movement discrimination in the extreme peripheral vision to better than 20/20 in the center of vision' (Spector, R.: 1990, Visual Fields); 'the spatial resolving powers of the visual system decline markedly as targets move away from central vision into the peripheral visual field' (Schieber, F.: 2003, p. 47). The absence of vision anywhere in the island of vision is an abnormal condition (Spector, R.: 1990, Visual Fields). One of its common causes is glaucoma. 'Glaucoma is a group of diseases that can damage the optic nerve and cause blindness. …….. Symptoms include loss of peripheral vision, starting with detail and increasing until the sufferers have a form of tunnel vision where they gradually lose all of their peripheral vision. If left untreated, this tunnel vision will continue to move inward until no vision remains' (Kurniawan, S.: 2009, p. 8-3). 'The sufferer has a decreased angle of vision and so must turn the head to view what a normal person could view in the peripheral vision' (ibid., p. 8-3). See also, Cerella, J. (1985).

- **Colour Vision:** It's the ability to distinguish objects based on the wavelengths (frequencies) of the light they emit (Kinzel, E.: 2009, p. 6-3) or perceive colour differences, under normal lighting conditions. Normal observers are capable of distinguishing among more than 100,000 hues in side-by-side comparisons (Geldard, F.: 1972). Perception of colour begins with specialized retinal cells, known as cone cells (Masland, R.: 2001, p. 878, 879).

  Cone cells, or cones, are 1 of 2 types of photoreceptor cells in the retina of the eye; cones are responsible for colour vision (perception of colour) and function best in relatively bright light, as opposed to rod cells, which work better in dim light (which support vision at low light levels). When light enters our eyes, it passes through the lens before reaching the cones of the retina (colour -sensitive cells). There are 3 different types of cone cells, each with a different pigment with different spectral sensitivities. Each cone is therefore sensitive to visible wavelengths of light that correspond to short wavelength, medium wavelength and medium-to-long wavelength light, with their peak sensitivities in the blue, green, and yellow-green regions of the spectrum, respectively. So, they are known as short (S), medium (M) and long (L) wavelength cones respectively, but are also often referred to as blue, green, and red cones, although this terminology is inaccurate. When different wavelengths of light fall on the 3 types of cone cells, they perceive colour in light and transmit that information to the optic nerve, in turn, to the brain, which produces our perception of shades of colour. (Masland, R.: 2001; NHS choices; Colblindor: 2010; NEI; Colour Blind Awareness: Causes of color blindness; and Wikipedia: Cone cell, Color blindness).

[1] The peripheral vision is a part of the vision that occurs outside the very centre of the gaze. There's a broad set of non-central points in the field of view that is included in the notion of peripheral vision. (Wikipedia: Peripheral vision)

Normal colour vision uses all 3 types of light cones correctly and is known as trichromacy. People with normal colour vision are known as trichromats (Colour Blind Awareness: Types of color blindness). Colour deficiency (colour blindness) can be attributed to many causes; the most common cause is a fault in the development of one or more sets of retinal cones (genetic cause); it can also be caused by an illness, a health condition, exposure to chemicals or some medications affecting the eye, the optic nerve or parts of the brain that process colour information; also, colour vision can decline with age (NEI; Colour Blind Awareness: Causes of color blindness; and NHS choices). There are 3 types of inherited colour vision deficiencies: monochromacy, dichromacy, and anomalous trichromacy[1].

- **Contrast sensitivity:** It refers to the ability of the visual system to distinguish bright and dim components of static objects (to discern among the luminance of different levels of static objects) (Kinzel, E.: 2009, p. 6-4 and Wikipedia: Contrast (vision)). It's an aspect of visual acuity (Hawthorn, D.: 2000, p. 509). It's a very important measure of visual function, especially in situations of low light, fog or glare, when the contrast between objects and their background often is reduced (Heiting, G.). It's assessed by measuring 'the minimum contrast needed to detect targets ranging in size from very small to very large' (Schieber, F.: 2003, p. 44).

  Contrast sensitivity can decline with age (Owsley, C.: 1983 and Sia, D.: 2013) and also due to certain eye conditions or diseases such as cataracts, glaucoma or diabetic retinopathy (Heiting, G.). Diminished contrast sensitivity may cause decreased visual function despite having normal visual acuity (Hashemi, H.: 2012 and Heiting, G.). Individuals with low contrast sensitivity have problems with night driving – including difficulty seeing pedestrians walking alongside poorly lit streets, tired eyes more easily while reading or watching TV, difficulty in seeing spots on clothes or dishes, and problems with other daily life activities in which contrast is reduced (Heiting, G.).

[1] Monochromacy (complete colour blindness) is the lack of ability to distinguish colours (and thus the person views everything as if it were on a black and white television); caused by cone defect or absence. Monochromacy occurs when 2 or all 3 of the cone pigments are missing and colour and lightness vision is reduced to one dimension. Dichromacy is a moderately severe colour vision defect in which one of the 3 basic colour mechanisms is absent, not functioning or has a limited function). Dichromacy occurs when one of the cone pigments is missing and colour is reduced to 2 dimensions. Dichromacy conditions are labeled according to the affected photoreceptors; protanopia refers to a condition in which the (L) wavelength cones are affected, deuteranopia refers to a condition in which the (M) ones are affected, and tritanopia refers to a condition in which the (S) ones are affected. Both protanopia and deuteranopia are known as red-green colour blindness and tritanopia as blue-yellow colour blindness. Anomalous trichromacy is a common type of inherited colour vision deficiency, occurring when one of the 3 cone pigments is altered in its spectral sensitivity. (Colblindor: 2010; NEI; Colour Blind Awareness: Types of color blindness; and Wikipedia: Color blindness)

- **Dark Adaptation:** 'The sudden transition from a high level of ambient illumination to a very low one is accompanied by a significant reduction in visual sensitivity. Some portion of this loss in light sensitivity is typically recovered once the visual system has had a chance to adapt to the lower level of illumination.' (Schieber, F.: 2003, p. 44)
- **Disability Glare:** Visual acuity (and related visual functions) is significantly impaired in the presence of peripheral glare sources – especially with low contrast stimuli (ibid.).

Briefly, all the above-mentioned visual aspects or sub-functions form together the function of sight – the function of the visual system – defined as the ability to sense the presence of light and sense the form, size, shape and colour of the visual stimuli (WHO: 2001, p. 62).

6.3.2. The Auditory system:

Similar to the visual system, the auditory system is a sensory nervous system. It's responsible for processing the perceived auditory information (the process of hearing). It consists of the ears (incl. the external, middle and inner ear), neural pathways and parts of the brain involved in auditory perception starting with the cochlear nucleus up to the primary auditory cortex. 'The ear is a very efficient transducer (i.e. a device that changes energy from one form to another), changing sound pressure in the air into a neural-electrical signal that is translated by the brain as speech, music, noise, etc.' (Dobie, R.: 2004, p. 44, 45). Thus, the auditory system is a transducer from the physical world to the realm of the mind where we interpret the information, creating our perception of the world around us. Each part of the auditory system has a specific role in this process (ibid.: p. 45). For more details, the parts of the auditory system and their functions are clarified below.

1. **The auditory system parts:** The auditory system consists of the following parts:

- **The ear** – fig. 6.3**:** It consists of:

- **The external ear**: It's the sound-collection system – it collects sound energy for transmission into the middle air (Turner, J.: 1990). It consists of the pinna, auditory canal and eardrum. The pinna includes the parts of the outer ear that appear as folds of cartilage forming a cup-shaped structure. They surround the ear canal and function as sound wave reflectors and attenuators when the waves hit them. The pinna helps the brain identify the direction from where the sounds originated. From the pinna, the sound waves enter a tube-like structure called the auditory canal. This canal serves as a sound amplifier. The sound waves travel through the canal and reach the tympanic membrane (eardrum) – the canal's end – which connects to the middle ear. (explorable.com/auditory-system and Kinzel, E.: 2009, p. 6-6)
- **The middle ear:** It consists of an air-filled cavity formed of a series of 3 delicate bones called ossicles (malleus, incus and stapes). They form a bridge between the outer and inner ear – the malleus is attached to the eardrum and the stapes is attached to a small membrane called the oval window covering the inner ear. As the sound waves hit the eardrum, the sensory information goes into the ossicles, through which the sound vibrations made when the sound waves hit the eardrum are converted into sound vibrations of higher pressure (still in the waveform) at the oval window. This higher pressure is necessary to move through the fluid beyond the membrane. But the sound isn't uniformly amplified across this chain. There are muscles within the middle ear, attached to the ossicles that act as protection for the inner ear. If the sound entering the middle ear is above a certain threshold, the muscles tighten to reduce the movement of the ossicles and thus control the transfer of energy onto the oval window. (Kinzel, E.: 2009, p. 6-6, 6-7 and explorable.com/auditory-system)

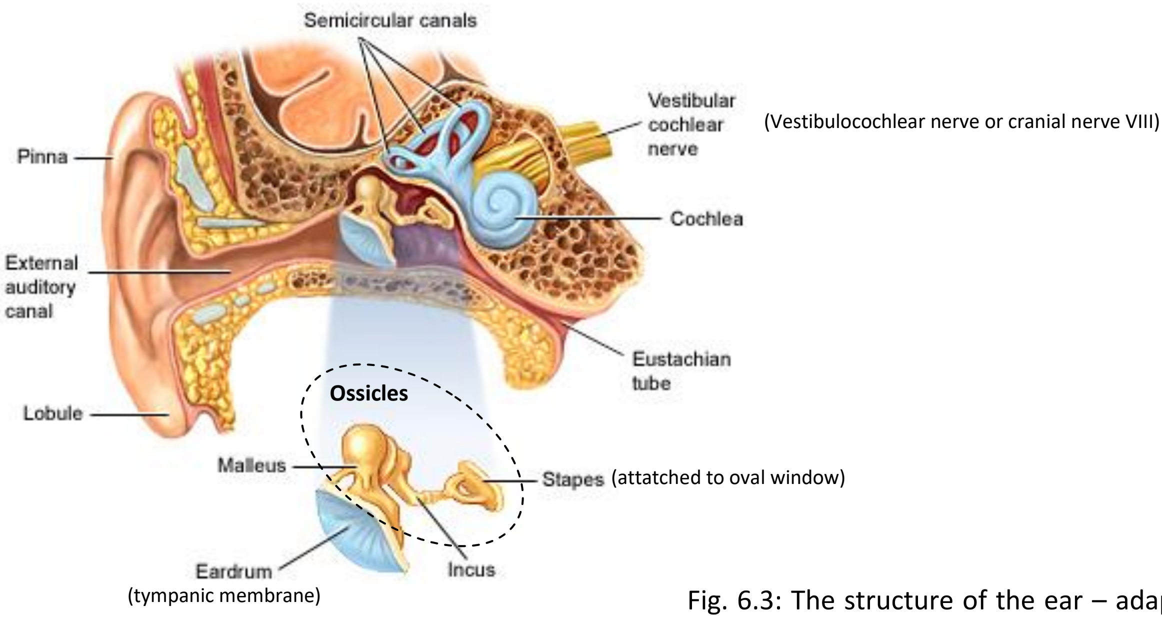


Fig. 6.3: The structure of the ear – adapted from (MedlinePlus: Ear anatomy)

- **The inner ear:** It lies beyond the oval window. This segment of the ear is filled with liquid rather than air, that is why there's a need for the conversion of low-pressure sound vibrations to higher-pressure ones in the middle ear. The inner ear is composed of semicircular canals and the cochlea. The main structure in the inner ear is the cochlea containing the hair cells that act as auditory receptors. In the cochlea, the sensory info in the waveform is transformed into a neural form. The cochlear duct contains the organ of Corti. This organ is comprised of inner sensorineural hair cells that turn the vibrations into electric neural signals. When motion occurs in the fluid within the inner ear – generated from the ossicles of the middle ear – the hair cells move. This bending of the hair cells initiates a neural signal. Each hair innervates many auditory nerve fibers, and these fibers form the auditory nerve. The auditory nerve (for hearing) combines with the vestibular nerve (for balance), forming cranial nerve VIII or vestibulocochlear nerve. (explorable.com/auditory-system and Kinzel, E.: 2009, p. 6-7)

- **Central neural parts:** There are many neural centres in the brainstem and the brain that process the information provided by the auditory nerve – the auditory part of cranial nerve VIII (Dobie, R.: 2004, p. 47). Once the sound waves are turned into neural signals, they travel through cranial nerve VIII, reaching different anatomical structures where the neural information is further processed – fig. 6.4. The cochlear nucleus is the first site of neural processing, followed by the superior olivary complex located in the pons, and then processed in the inferior colliculus at the midbrain. The neural information ends up at the relay centre of the brain, called the thalamus. The info is then passed to the primary auditory cortex of the brain, situated in the temporal lobe. The primary auditory cortex is the region where the basic characteristics of sound (pitch, rhythm, frequency, etc.) are processed – the cortical region responsible for the sensation of sound. (Tewfik, T.; Pujol, R.; Gil-Loyzaga, P. and explorable.com/auditory-system)

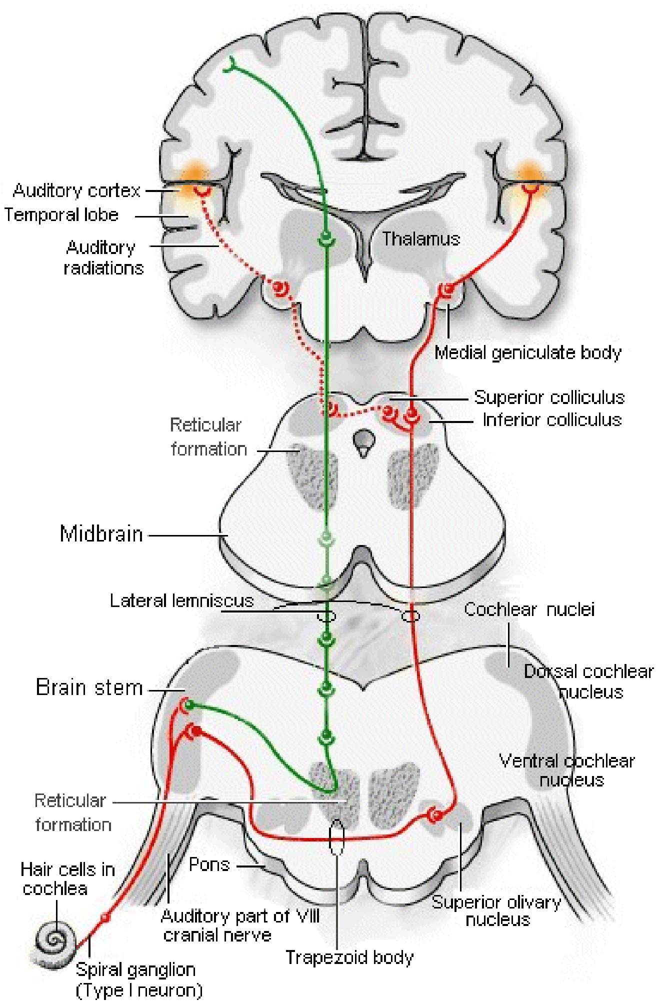


Fig. 6.4: An illustration of the afferent auditory reflex pathway (firstyears.org/anatomy/ear.htm and Pujol, R.)

The auditory nerve leaves the cochlea and carries the signal into the section of the brainstem known as the cochlear nucleus. From the cochlear nucleus, auditory information splits into (at least) two streams, shown here in red (which go to the ventral cochlear nucleus) and green (which go to the dorsal cochlear nucleus).

The ventral cochlear nucleus cells project to a collection of nuclei in the medulla called the olivary nucleus. There, minute differences in the timing and loudness of the sound in each ear are compared to localize sound. The superior olivary nucleus then projects up to the inferior colliculus via a fiber tract called the lateral lemniscus.

The second stream of information starts in the dorsal cochlear nucleus. This stream analyzes the quality of sound, picking apart the tiny frequency differences which make "bet" sound different from "bat" and "debt". This pathway projects directly to the inferior colliculus, also via the lateral lemniscus.

From the inferior colliculus, both streams of information proceed to the auditory nucleus of the thalamus, called the medial geniculate body. From there, the auditory radiations project to the primary auditory cortex (Heschl's Gyrus), located on the banks of the temporal lobes.

(firstyears.org/anatomy/ear.htm)

Thus, the hearing function is conveniently considered as occurring in 2 phases: conductive phase and sensorineural phase. The conductive phase involves the collection and passage of mechanical vibratory sound energy from the gaseous medium of the environment to the fluid medium of the inner ear. The sensorineural (sound) phase begins in the cochlea where the hair cells of the Corti organ transduce vibratory energy into electric potentials; the coding of loudness and pitch occurs here; this information is transmitted via the auditory nerve and brainstem through several intervening nuclear synapses to the auditory cortex for decoding and understanding. (Turner, J. and Per-Lee, J.: 1990)

The ear along with the auditory nerve make up the peripheral auditory system, and the brainstem and brain constitute the central auditory nervous system; and both systems are responsible for hearing and auditory perception (Dobie, R.: 2004, p. 47). The cognitive processes involved with perceiving sound are complex; multiple levels of processing occur at each stage of sensory processing; these stages range from registering the stimulus on the receptor to a final conscious representation in memory (Kinzel, E.: 2009, p. 6-7).

2. **Aspects of hearing:** Evaluating the performance of an individual's auditory system – the function of hearing – is through evaluating many auditory aspects or sub-functions that express the performance level of the auditory system parts singly and collectively. Before going into more details regarding those auditory aspects, it should be mentioned that a sound waveform has 3 basic physical attributes: frequency, amplitude, and temporal variation.

Frequency refers to the number of times per second that the vibratory pattern oscillates. Frequency is measured in units of hertz (Hz), cycles per second. Amplitude refers to sound pressure which is proportional to sound intensity (in units of power or energy), so sound magnitude can be measured in units of pressure, power and energy. The common measure of sound level is the decibel (dB) – dB SPL (sound pressure level) – in which the decibel is the logarithm of the ratio of 2 sound intensities or 2 sound pressures. There are many aspects to the temporal variation of sound, such as sound duration. Measures of time are expressed in various temporal units or can be translated into phases measured in angular degrees. (Dobie, R.: 2004, p. 43)

As the frequency of a sound changes, so does its subjective pitch. Pitch is the subjective attribute of sound that allows one to determine if the sound is high or low along a single perceptual dimension. Also, as the intensity of a tone increases, so does its subjective loudness. Loudness is a subjective indication of the magnitude of sound (ranging from quiet to loud). While loudness is highly correlated with sound intensity and pitch with frequency, loudness and pitch are subjective attributes of sound that may be correlated with each of the physical attributes of sound: frequency, level, and temporal properties. So for instance, a change in sound frequency may result not only in a change in pitch but also in a change in loudness. (ibid.: p. 50, 51)

Back to the auditory aspects of the hearing function, outlined in the following[1]:

[1] Most of the description of the auditory aspects is derived from the book: *Hearing Loss: Determining Eligibility for Social Security Benefits* – by Robert A. Dobie and Susan Van Hemel (2004), pp. 48: 59.

- **Sound detection**: It's the sensory function 'relating to sensing the presence of sounds' (WHO: 2001, p. 65). The healthy, young auditory system can detect tones in quiet with frequencies ranging from approx. 20 to 20000 Hz (Dobie, R.: 2004, p. 48); taking into account that the majority of human speech sounds range from 300 to 3000 Hz (Turner, J. and Per-Lee, J.: 1990). With regards to the sound level, in the frequency region (between 500 and 4000 Hz) in which the human auditory system is most sensitive, the range of hearing covers approx. 130 dB[1] (Dobie, R.: 2004, p. 48). 'The thresholds for detecting a tonal sound increase as the duration of the sound to be detected decreases at durations shorter than 500 ms, but remain approximately constant as the duration increases above 500 ms' (ibid.).

  While a young healthy person can detect a signal sound over the frequency range of 20 to 20000 Hz, the level of the signal sound required for detection depends on the frequency of the sound, the duration of the sound, and the nature of any other sound that may be present at or near the same time as the signal sound that may mask the signal sound – detecting threshold[2] of a signal sound has been elevated by the presence of the masking sound. ……. Spectrally similar sounds (the same frequency components) are more likely to mask each other than are sounds that aren't spectrally similar. Signals are most difficult to detect when a masker and signal occur at the same time, but masking can occur when the signals and maskers don't temporally overlap. All of these measures of auditory perception can be adversely affected if a person has a hearing loss. (Dobie, R.: 2004, p. 52)

- **Sound discrimination:** It's the sensory function 'relating to sensing the presence of sound involving the differentiation of ground and binaural synthesis, separation and blending' (WHO: 2001, p. 65). Over a range of frequencies (approx. 500 to 4000 Hz) and levels (approx. 35 to 80 dB SPL) in which humans are most sensitive, listeners can discriminate a change of about 1 dB in sound level and about 0.5% change in tonal frequency. For instance, a 50 dB SPL sound can be discriminated from a 51 dB SPL sound, and a 2000 Hz tone can be discriminated from a 2010 Hz tone. A hearing loss can lead to elevated level and frequency difference thresholds, making it difficult for the person with a hearing loss to discern the small differences in level and frequency that often accompany changes in the speech waveform. (Dobie, R.: 2004, p. 52, 53)

[1] The normal sound intensity is at 60 dB. Starting from 90 dB onwards, damage infects the ear if it's exposed to the sound of this intensity for a long time. This destroys hearing cells, which aren't renewed. If an individual is exposed to high sounds above 90 dB for a long time, he/she loses hearing slowly. For this, we find diggers working on electric excavators and planes guides on the ground are using ear protection tools. (Wikipedia: Decibel)

[2] The presence of another sound (masking sound) presented at the same time as a tone that is to be detected (signal tone) may increase the threshold of the signal tone above that measured in quiet. (Dobie, R.: 2004, p. 51)

With regards to the temporal variation, long-duration sounds require a larger change in duration for duration discrimination than do shorter-duration sounds (ibid.: p. 53).

All of these measures of sound discrimination don't change appreciably as a function of the presence of masking sounds as long as the signal sound is readily detectable. Many people with hearing loss, especially the elderly, have difficulty processing the temporal structure of sounds. These people usually have high temporal difference thresholds, and they require slow rates of amplitude fluctuation to discriminate a fluctuating sound from a steady sound. Thus, people with such losses may not be able to follow some of the rapid fluctuations in sound intensity that are present in many everyday sounds, such as speech and music. Thus, in the workplace, very small changes in sound level, frequency and duration can be discriminated even when some masking sounds also exist. As long as the level of a sound doesn't vary too rapidly, listeners in the workplace should be able to determine that the sound is fluctuating in level (in loudness). People with hearing loss often perform less well in these auditory discrimination tasks than people with normal hearing. (ibid.: p. 53)

- **Speech discrimination:** It's the sensory function 'relating to determining spoken language and distinguishing it from other sounds' (WHO: 2001, p. 65). The intelligibility of speech processed in quiet by listeners with normal hearing is somewhat resistant to many forms of physical alterations. Speech can be filtered (allowing only selected frequencies to be presented), speeded up or slowed down, clipped in amplitude, etc., and still be intelligible in a quiet listening environment. However, speech is susceptible to masking or interference from other competing sounds, especially other speech sounds. One rule of thumb for listeners with normal hearing is that for a broadband masking stimulus such as white noise[1], approx. 50% intelligibility occurs when only the speech and noise information is provided and the overall levels of the speech words or syllables and noise are about equal (i.e. when the S/N ratio is zero dB). However, many conditions can alter the relationship between the S/N ratio (the ratio of the speech signal level to masker/noise level) and performance. Listeners with hearing loss often have much more difficulty in recognizing speech that is altered, and their S/N ratio is usually greater than zero dB. However, the higher the fidelity of the sound reproduction system, the better speech recognition is likely to be when interfering sound sources are present. Hearing loss can lead to a significant loss of speech recognition even with high-quality amplification systems. (Dobie, R.: 2004, p. 54, 55)

  Many different speech recognition tests have been developed to assess hearing loss, to help ensure that the results are valid indicators of the relationship between speech recognition and hearing loss.

[1] Noise is a complex sound that contains all frequency components, and whose instantaneous amplitude varies randomly. White noise is a noise in which all of the frequency components have the same average level. (Dobie, R.: 2004, p. 44)

Speech tests are usually designed to determine if only one or maybe a small number of variables affect the ability of the subject or patient to recognize speech. For instance, many speech tests are intended to determine how much difficulty a person with a high-frequency hearing loss might have in recognizing speech. If the speech test consists of words that the patient isn't familiar with, then poor performance on the test might indicate a difficulty with vocabulary rather than a hearing loss. Using test words in a language in which the patient isn't fluent could also confound the assessment of hearing loss. (ibid.: p. 53, 54)

- **Localization of sound source:** It's the sensory function 'relating to determining the location of the source of sound' (WHO: 2001, p. 65). The source of a sound can be located in 3 spatial dimensions as a function of the auditory system's ability to process the sound emanating from a sound source. These dimensions are azimuth — the direction from the listener in the horizontal plane, elevation — the vertical or up-down dimension, and range – the distance or near-far dimension. A different set of cues is used by the auditory system to locate sound sources in each spatial dimension (Dobie, R.: 2004, p. 55). For example, sounds from sources located off-centre in the azimuth direction arrive at one ear before they arrive at the other ear, and the sound at the near ear is more intense than the sound at the far ear; thus, interaural differences of time and level are the 2 cues used for azimuthal (directional) sound localization (ibid.: p. 55). Additionally, faraway sounds are usually softer than near sounds, thus loudness cue can be used to determine the distance of a sound source, assuming the listener has some knowledge about the nature of the source (i.e. some knowledge about how intense the sound is at the source) (ibid.: p. 57).

  Locating sound sources can be more difficult for people with hearing loss. This is especially true for listeners with unilateral hearing loss. If a single hearing aid or cochlear prosthesis is used, it may provide only limited assistance for sound localization, since binaural processing is required to locate sounds in the horizontal plane. However, fitting each ear with a hearing aid or cochlear prosthesis doesn't always assist the patient in sound localization. In most cases, the 2 aids or prostheses don't preserve all of the acoustic information required by the auditory system to localize a sound source. In short, having a hearing loss can compromise a person's ability to locate sounds, and hearing aids may not assist him or her in locating sound sources. (ibid.: p. 57)

  In reverberant spaces, the sound waveform reflects off the many surfaces, resulting in a complex pattern of sound arriving at the ears of a listener. Listeners are usually not confused about the nature of the actual sound source, including its location. Rooms that are large and reflective have long reverberation times. People with hearing losses often perform very poorly in reverberant spaces, and the poor performance may persist even when they use a hearing aid or cochlear prosthesis. That is, people with hearing loss have difficulty recognizing speech signals when the reverberation time is long, especially if the acoustic environment is also noisy. (ibid.: p. 57, 58)

- **Sound Source Determination:** The human is remarkably good at determining many of the sources of sounds, even when most of the sounds from these sources are occurring at the same time. Little is known about how the auditory system accomplishes the task of auditory scene analysis, but several potential cues and neural processing strategies have been suggested as ways in which the sources of many sounds can be processed and segregated in a complex, multisource acoustic environment. People with hearing loss often remark that they have problems in noisy situations, such as at a cocktail party, implying that they aren't able to determine the auditory scene as compared to people without hearing loss. Listeners with normal hearing can use many potential cues to determine different sound sources in the workplace, even when these sounds from the sources overlap in time and perhaps in space. (ibid.: p. 58, 59)

Briefly, all the above-mentioned auditory aspects or sub-functions form together the function of hearing – the function of the auditory system – defined as the ability to sense the presence of sounds and discriminate the location, pitch, loudness and quality of sounds[1] (WHO: 2001, p. 65). Through the auditory system, 'listeners can detect the presence of a sound; discriminate changes in frequency, level, and time; recognize different speech sounds; localize the source of a sound; and identify and recognize different sound sources' (Dobie, R.: 2004, p. 48). An interfering sound may make it difficult to detect another sound, discriminate among different sounds or identify a particular sound (ibid.: p. 48). A hearing loss may make it difficult to perform one or all of these auditory sub-functions even in the absence of interfering sounds but especially in the presence of interfering sounds (ibid.: p. 48).

[1] The quality of sound is known as timber, tone colour or tone quality.

6.3.3. The cognitive system:

In humans, the cognitive system is responsible for providing the individual with some specific mental functions[1] (higher functions of the human brain) – known as cognitive functions and forming together the cognition or the mind. Those functions are related to how sensory information[2] within the human brain is represented (identified), processed, transformed and used upon request to influence an attitude or action (decision-making/a behavioural response selection). This process is a subsequent phase to the phase of sensory stimulation. This system consists of some parts of the brain involved in the dynamics of the information state, thus it's considered a part of the nervous system. The cognitive process, starting with becoming aware of a sensory stimulus[3] (a stimulus identification – perception) and ending with using that processed information to influence an action (a response selection) (Donders, F.: 1969), is an intermediate phase between the sensory stimulation phase and the action phase. Perception, attention, memory, the mental function of language, calculation and intelligence (higher-level cognitive functions such as abstraction, insight, problem-solving, reasoning and decision-making) are examples of the cognitive functions or aspects. They are briefly explained in the following.

Aspects of cognition:

- **Perception**: It's 'the organization, identification, and interpretation of a sensation (sensory information) in order to form a mental representation' (Schacter, D.: 2011, p. 127, G-8). It's a specific mental function of recognizing and interpreting sensory stimuli (WHO: 2001, p. 55). For example, visual perception is a mental function involved in discriminating shape, size, colour and other ocular stimuli; and olfactory perception is a mental function involved in distinguishing differences in smells (WHO: 2001, p. 55, 56). Perception is the process of becoming aware of a sensory stimulus. It's the ability to take in information via the senses, and process it in some way (Wikipedia: Cognitive science). This process is elaborated as follows; with a presentation of a sensory stimulus, physical or chemical stimulation of the sensory organ occurs, emitting signals in the related nervous parts, by which the brain receives such stimulus; then, the brain transforms such low-level information of sensory input to higher-level information (Goldenstein, E.: 2009, pp. 5: 8) according to each individual. Perception isn't the passive

[1] Mental functions are functions of the brain: both global mental functions, such as consciousness functions, orientation functions, temperament and personality functions, energy and drive functions and sleep functions (WHO: 2001, pp. 48: 52); and specific mental functions, such as attention, memory, language and calculation mental functions. (ibid.: p 48, pp. 53: 61)

[2] Incoming data always provides the starting point of perception (Goldenstein, E.: 2009, p. 10).

[3] Stimulus is what we actually pay attention to, and what stimulates our receptors; it refers to what is out there in the environment, and within the person's body (ibid.: 2009, p. 5).

receipt of these signals but is shaped by the person's concept and expectations (his existing knowledge[1]), memory, and selective mechanisms (attention). See, Bernstein, D.: 2011, 83: 131 and Goldenstein, E.: 2009, pp. 5: 12.

- **Attention:** It's a specific mental function of focusing on (producing concentration for) an external stimulus or internal experience for the required time (WHO: 2001, p. 53). It's the ability to focus and remember items needed for the performance of a task (Hawthorn, D.: 2000, p. 515) in the face of distracting stimuli being presented, which may have to be processed simultaneously mentally (Kurniawan, S.: 2009, p. 8-4). Whereas shifting attention is a specific mental function that permits refocusing concentration from one stimulus to another, dividing attention is a specific mental function that permits focusing on (paying attention to) 2 or more stimuli/tasks at the same time (WHO: 2001, p. 53 and Hawthorn, D.: 2000, p. 515).

- **Memory:** It's a specific mental function of registering and storing information and retrieving[2] it as needed (WHO: 2001, p. 53, 54). It includes short-term, long-term and working memory.

- Short-term memory or active memory is a mental function that produces a temporary, disruptable memory store of around 30 seconds duration from which information is lost if not consolidated into long-term memory (WHO: 2001, p. 54). It reflects the faculties of the human mind that can hold a limited amount of information in a very accessible state temporarily – in an active, readily available state for a short period (Atkinson, R. C.: 1968 and Cowan, N.: 2008). 'Information stored in short term memory is displaced by new information coming in and so is lost rapidly over time unless transferred to long term memory' (Hawthorn, D.: 2000, p. 517). In general, it refers to the short-term storage of information and it doesn't entail the manipulation or organization of material held in memory (Wikipedia: Short-term memory). Thus, it should be distinguished from working memory.

- Long-term memory or reference memory is a mental function that produces a memory system permitting the long-term storage of information (WHO: 2001, p. 54). It's a vast store of knowledge and a record of prior events, and it would be difficult to deny that each normal person has at his or her command a rich set of long-term memories (Cowan, N.: 2008). In contrast to short-term and working memory, information can remain in long-term memory indefinitely (Wikipedia: Long-term memory) – in long-term memory, data can be stored for long periods. Short-term memory is limited to a certain number of chunks of information, while long-term memory has a limitless store (Miller, G. A.: 1956 and Cowan, N.: 2008). It's commonly broken down into explicit and implicit memory. The explicit memory (declarative memory) refers to all consciously available memories; it includes episodic memory for

[1] Knowledge is any information the person brings to a situation. (Goldenstein, E.: 2009, pp. 9)

[2] Retrieval of memory is a specific mental function of recalling information stored in long-term memory and bringing it into awareness. (WHO: 2001, p. 54)

specific events in time, as well as supporting their formation and retrieval, semantic memory which holds information about the meaning of the components of one's world (factual information, such as the meaning of words), and autobiographical memory (events and personal experiences from an individual's own life). The implicit memory (procedural memory) refers to all memories holding the knowledge of how tasks are carried out – it refers to the use of objects or movements of the body, such as how exactly to use a pencil, drive a car or ride a bicycle (Atkinson, R. C.: 1968 and Hawthorn, D.: 2000, p. 517).

- Working memory is the system that is responsible for the transient holding and processing of new and already stored information, a process for reasoning, comprehension, learning and memory up-dating (Wikipedia: Working memory). It refers to structures and processes used for temporarily storing and manipulating information (Wikipedia: Short-term memory). It holds and manipulates information for a short period before it's either forgotten or encoded into long-term memory; then, to remember something from long-term memory, it must be brought back into working memory (Ranganath, C.: 2005 and Axmacher, N.: 2010). If working memory is overloaded it can affect the encoding of long-term memory; if one has a good working memory they may have a better long-term memory encoding (ibid.). Thus, working memory isn't part of long-term memory, but it's essential for the functioning of long-term memory (Wikipedia: Long-term memory). Also, 'working memory is not completely distinct from short-term memory. It is a term that was used by Miller. G. et al. (1960) to refer to memory as it is used to plan and carry out behavior. One relies on working memory to retain the partial results while solving an arithmetic problem without paper, to combine the premises in a lengthy rhetorical argument, or to bake a cake without making the unfortunate mistake of adding the same ingredient twice' (Cowan, N.: 2008). According to Cowan, N., 'working memory includes short-term memory and other processing mechanisms that help to make use of short-term memory' (ibid).[1]

- **Mental function of language:** It's a specific mental function of recognizing and using signs, symbols and other components of a language. It's a specific mental function of reception and decryption of spoken, written or other forms of language such as sign language, to obtain their meaning; production of spoken, written or other forms of language; and organizing semantic and symbolic meaning,

[1] For more clear differences among long-term, short-term, and working memory, Cowan, N. (2008) indicated that 'long- and short-term memory could differ in two fundamental ways, with only short-term memory demonstrating (1) temporal decay and (2) chunk capacity limits. Both properties of short-term memory are still controversial but the current literature is rather encouraging regarding the existence of both decay and capacity limits. Working memory has been conceived and defined in three different, slightly discrepant ways: as short-term memory applied to cognitive tasks, as a multi-component system that holds and manipulates information in short-term memory, and as the use of attention to manage short-term memory' (Cowan, N.: 2008, abstract).

grammatical structure and ideas for the production of messages in spoken, written or other forms of language (WHO: 2001: p. 58, 59).

- **Calculation:** It's a specific mental function of determination, approximation and manipulation of mathematical symbols and processes. It includes computing with numbers, such as addition, subtraction, multiplication and division; and translating word problems and mathematical formulas into arithmetic procedures, and other complex manipulations involving numbers (ibid.: p. 60).
- **Intelligence (Higher-level cognitive functions):** They are specific mental functions relating to complex goal-directed behaviours such as decision-making, abstraction, planning and carrying out plans, time management, mental flexibility, insight, judgment, evaluation, concept formation, problem-solving, reasoning and deciding which behaviours are appropriate under what circumstances (ibid.: p. 57, 58). They often are called executive functions and are dependent on the frontal lobes of the brain (ibid.: p. 57).

Briefly, all the above-mentioned cognitive aspects or sub-functions form together the cognition (intellectual functioning) – the function of the cognitive system – defined as the ability of the human mind to process information, hold attention, store and retrieve memories, use reasoning skills and select appropriate responses and actions – decision-making (Ashok, M.: 2009, p. 4-6 and Waller, S.).

On a closer level, evaluating the performance of an individual's cognitive system – the function of cognition – is through evaluating the previous cognitive functions or aspects that express the performance level of the cognitive system structures singly and collectively. On a less representative level, evaluating the performance of an individual's cognitive system is through measuring the speed and quality of a response selection which reflects not only the efficiency of the cognitive system (speed and quality of the central processing) but also the efficiency of the related sensory system (quality of sensory information and speed of delivering them to the brain).

It's worth mentioning that the speed of delivering sensory information to the brain, cognitive processes (central processing), and delivering impulses from the brain to related organs executing the behaviour response, form together the speed of response initiation measured by what is known as reaction time (RT).

RT is defined as the time required to initiate a behavioural response following a sensory signal (Ketcham, C.: 2004). It's the elapsed time between the presentation of a sensory stimulus and the initiation of a subsequent behavioural response (Jensen, A.: 2006, p.11). It's thought to reflect the speed of transmission of the central nervous system (Ketcham, C.: 2004). It's considered to be an index of processing speed (Jensen, A.: 2006, p.). 'Some researchers have sought to decompose reaction time into premotor and motor time. Premotor time is defined as the time from the presentation of the stimulus until the onset of muscle activity and is thought to reflect cognitive processes, whereas motor time is the time from muscle activation to the beginning of the movement and reflects efficiency of the motor system' (Ketcham, C.: 2004). The sum of RT and time of executing a behavioural response[1] (e.g. MT) forms the response time which expresses the response speed (Wikipedia: Mental chronometry). While RT is thought to be controlled by personal factors representing in the response encoding processes, the central nervous system in general and perceptual-motor processes (i.e. stimulus encoding, memory set size, speed/accuracy trade-off), and external factors such as task complexity; MT is thought to be caused by, speed-accuracy trade-off and task complexity (Kurniawan, S.: 2009, p. 8-4, 8-5). The majority of studies have used RT (Lupinacci, N.: 1993) and MT (Smith, M.: 1999) as measures of performance (Kurniawan, S.: 2009, p. 8-4).

It should also be noted, that a consciously controlled response may be converted to an automated one. An automated response is the ability to respond to stimuli automatically without conscious effort or control (Hawthorn, D.: 2000, p. 516). An automated response can occur in parallel with other activity and is seen as allowing actions which don't contribute to cognitive load. An example is typically taken from motor activity such as braking or gear changing while driving (Bargh, J.: 1992). Such responses need to be learnt before they become automated, once learnt there's difficulty in unlearning the automated response since it's no longer under conscious control (Hawthorn, D.: 2000, p. 516).

[1] The behavioural response may be a button press, an eye movement, a vocal response, a movement or some other observable behaviour.

6.3.4. The motor system:

It is the executive system of most of the individual's behavioural responses that express the action phase that respectively follows both the sensory stimulation phase and the cognitive processes phase ending with selecting a response. Body movements are motor responses for performing most of our daily tasks; such as walking to the kitchen, eating breakfast, or taking a shower, all require multiple muscles that innervate body parts to move properly to complete such tasks. The motor system consists of the motor skeleton[1] (incl. bones, cartilages, ligaments and tendons; together forming joints)[2], attached skeletal muscles[3],

---

[1] Not all parts of the human skeleton are parts of the motor skeleton. Some parts of the skeletal system act as a protective structure for vital organs; such as the skull which protects the brain and the rib cage which protects the lungs. (InnerBody: Skeletal System)

[2] Cartilage is a flexible supportive tissue that prevents the bone ends from rubbing directly onto each other (Wikipedia: human musculoskeletal system). A ligament is a small band of dense, white, fibrous elastic tissue, which connects the ends of bones to form a joint (ibid.). Tendons are tough bands of dense regular connective tissue whose strong collagen fibers firmly attach muscles to bones (InnerBody: Muscular System). A joint (an articulation) is the area where 2 bones are attached to permit body parts to move; it's usually formed of fibrous connective tissue and cartilage (eMedicine Dictionary: Joint). In a joint, bones don't directly contact each other; instead, they are cushioned by cartilage in the joint, synovial membranes around the joint, and fluid (MedlinePlus: Aging changes ….).

[3] There are 3 types of muscles – cardiac, skeletal and visceral (smooth); only the skeletal muscles can move the body. Skeletal muscles are the only voluntary muscle tissues in the human body. Every physical action that a person consciously performs (e.g. speaking, walking, or writing) requires skeletal muscles. The function of skeletal muscles is to contract to move parts of the body closer to the bone that the muscle is attached to. Most skeletal muscles are attached to 2 bones across a joint, so the muscle serves to move parts of those bones closer to each other. Besides the movement as the main function of the muscular system, another function is the maintenance of posture and body position. Muscles often contract to hold the body still or in a particular position rather than to cause movement. (InnerBody: Muscular System)

The tissue of skeletal (voluntary) muscle consists of fibers; which can be divided into 2 types based on how they produce and use energy: Type I and Type II (slow and fast-twitch fibers). Type I fibers are very slow and deliberate in their contractions, and are very resistant to fatigue; they contract for long periods but with little force. They are found in muscles throughout the body for stamina and posture; such as near the spine and neck regions. Very high concentrations of type I fibers hold the body up throughout the day. Type II fibers contract quickly and powerfully but fatigue very rapidly – sustaining only for a short period. According to the contractile speed and force generated, type II fibers are broken down into 2 subgroups: type II A and type II B. Type II A fibers are faster and stronger than type I fibers, but don't have as much endurance; they are found throughout the body, but especially in the legs where they work to support your body throughout a long day of walking and standing. Type II B fibers are even faster and stronger than type II A, but have even less endurance; they are found throughout the body, but particularly in the upper body where they give speed and strength to the arms and chest at the expense of stamina. (InnerBody: Muscular System and Wikipedia: Muscle)

These 3 different types of fibers are specialized to have unique functionalities; type I fibers are described as high endurance but low Force/Power/Speed production of force (contraction speed) – fatigue-resistant, low -force and slow-twitch muscle fibers; type II B as low endurance but high Force/Power/Speed production – less motor neurons[1], neuromuscular junctions[2], proprioceptors[3], proprioceptive neurons[4] and parts of the brain[5]. The skeletal muscle fibers, motor neurons and neuromuscular junctions form together the motor units[6]. Each body organ – consisting of the previous elements – is a part of the whole motor

---

fatigue-resistant, high-force and fast-twitch muscle fibers; and type II A fibers are characterized in between the two (Wikipedia: Motor Control). Within a muscle, there will be several different combinations of these 2 types of fibers type I and type II (Sypert, G.: 1981).

[1] Motor neurons are mediators of messages or impulse signals (conduct electrical currents, carry the motor commands or deliver information) from the brain to skeletal muscles fibers innervated by the motor neurons' axonal terminals. They include both the upper and lower motor neurons (Schwerin, S.: 2013 and Bassett, S.: 2012).

[2] A neuromuscular junction is an intersection at which the motor neuron is able to transmit a signal to the muscle fiber, causing it to contract (ibid.).

[3] A proprioceptor is a sensory receptor that receives stimuli from within the body, especially that responding to position and movement. They include proprioceptors in skeletal striated muscles (muscle spindles), in tendons (Golgi tendon organ), and in joints (fibrous capsules) which sense the relative positions of the parts of the body and the strength of effort being employed in movement (Ketcham, C.: 2004; Bassett, S.: 2012; MedTerms medical dictionary: Proprioception; Wikipedia: Proprioception and Wikipedia: Sense). Impairments in these parts result in sudden and deep deficits in perception and action.

[4] Proprioceptive neurons are sensory neurons that deliver proprioceptive information on the relative positions of the parts of the body from proprioceptors to the parietal cortex of the brain (ibid.). Impairments in these neurons result in sudden and deep deficits in perception and action.

[5] One of the brain functions is controlling and coordinating the various components of the motor system to act in unison to produce movement or posture through sensing the relative positions of the body parts and sending out impulse signals to the specific motor units of relative skeletal muscles in a coordinated way according to the suggested way of execution.

[6] A motor unit consists of one motor neuron and its many innervated muscle fibers (Medical dictionary: Motor unit) – being from the same muscle fiber type. Every skeletal muscle consists of a number of motor units; the fibers belonging to a motor unit are dispersed and intermingle amongst fibers of other units; the muscle fibers of one motor unit can be spread throughout the part or most of the whole muscle (Ounjian, M.: 1991 & Bodine-Fowler, S.: 1990). The number of muscle fibers within each unit can vary within a particular muscle and even more from muscle to muscle; the size of motor units varies throughout the body, depending on the function of a muscle (InnerBody: Muscular System and Buchtal, F.: 1980). Muscles that perform fine movements (smaller muscles) – like those of the eyes or fingers – have very few muscle fibers in each motor unit to improve the precision of the brain's control over these structures; muscles that need a lot of strength to perform their function (muscles that act on the largest body masses) – like leg or arm muscles – have many muscle fibers in each motor unit (ibid.). Whatever the size of a muscle, its larger motor units are typically composed of faster muscle fibers that generate higher forces (type II fibers), and its smaller motor units are typically composed of slow muscle fibers that generate lower forces (type I fibers) (Motorneuron mapping). Motor neurons controlling fast-twitch muscle fibers (type II) tend to innervate relatively large numbers of these larger muscle fibers (e.g. 1000), and they have relatively large cell bodies and large-diameter axons that conduct action potential at higher speeds (e.g. 100 m/s); motor neurons controlling slow-twitch muscle fibers (type I) are smaller, slower and innervate smaller numbers of thinner muscle fibers, resulting in slower force output (ibid.).

system and could be considered a motor system per se; e.g. arms, hands, legs and feet. The motor system is called the neuromusculoskeletal system; it consists of parts from 3 different body systems: the muscular, skeletal and nervous systems. It gives the basic structure of body, the ability for movement, and the maintenance of posture and body position.

The skeleton provides support, form and structure to the body; joints allow the skeleton to be flexible for movement; and muscles provide the force and strength to move the body or maintain posture (MedlinePlus: Aging changes ….). Motor neurons ending with neuromuscular junctions transport the impulse signals from the brain to the skeletal muscle fibers to contract. Proprioceptors send information about the positions of the parts of the body through their connected proprioceptive sensory neurons to the brain. The brain controls and coordinates the various components of the motor system to act in unison to produce movement or posture. Actually, the motor system is highly complex, composed of many interacting parts at many different organizational levels (Wikipedia: Motor Control).

When a person wants to move his body (gives a motor response), to achieve a certain task, the brain senses the relative positions of the parts and instantly sends out impulse signals in a coordinated way that reach the specific motor units[1] of relative skeletal muscles according to the suggested way of

[1] When a motor neuron is activated, all of the muscle fibers innervated by the motor neuron are stimulated and contract at the same time (InnerBody: Muscular System), resulting in a weak but distributed muscle contraction (Wikipedia: Motor unit recruitment). The activation of more motor neurons will result in more muscle fibers being activated, and therefore a stronger muscle contraction; the higher the number of activated motor units the stronger the muscle contraction will be (ibid.). 'One of the ways that the body can control the strength of each muscle is by determining how many motor units to activate for a given function. This explains why the same muscles that are used to pick up a pencil are also used to pick up a bowling ball' (InnerBody: Muscular System). Thus, muscles which possess more motor units (and thus have greater individual motor neuron innervation) are able to control force output more finely (Wikipedia: Motor unit).

The brain is responsible for the orderly recruitment of motor neurons. Motor units of a muscle are generally recruited in order of increasing size (smallest to largest and thus slow to fast-twitch) based on the size of the load (Motorneuron mapping). When only a small amount of force – such as typing on the keyboard – is required from a muscle with a mix of motor unit types, this force is provided exclusively by the smaller (slow -twitch) motor units that contract much slower and thus provide less force – they contain type I fibers; as more force is required, larger (fast-twitch) motor units containing type II fibers are progressively recruited, normally in a remarkably precise order based on the magnitude of their force output (ibid.). For example, lifting heavy objects, not only does low-threshold motor units, but also the high-threshold ones are recruited to compensate forces required in addition to just holding a fork, in which the energy created by the low-threshold motor units is sufficient to complete the job (Wikipedia: Motor control). 'This serves two important purposes: it minimizes the development of fatigue by using the most fatigue-resistant muscle fibers most often (holding less fatigue -resistant fibers in reserve until needed to achieve higher forces); and it permits equally fine control of force at all levels of force output (e.g, using smaller motor units when only small, refined amounts of force are required)' (Motorneuron mapping).

execution; in turn, skeletal muscle fibers of such motor units contract and muscles generate forces which actuate joints, thus creating the desired movement or action (Wikipedia: Motor Control). This brain function[1] of activating and coordinating the muscles and limbs involved in the performance of a movement or consecutive or parallel movements for an action is called motor control (ibid.).

Here, it's worth mentioning that the motor control process – as a mental function – is subsequent to a set of cognitive processes (specific mental functions). This set starts with perception – identification of the internal and external sensory stimuli[2] (sensory information about the world and the current state of the body) – and ends with response selection (decision-making). Whereas in perception, the relevant information about objects, environments and bodies (inputs) used in organizing and executing actions and movements, is provided; in response selection, processed information through intermediate cognitive processes[3] is used in determining the suitable actions and movements (determining out-puts), the execution way of doing them, and the appropriate set of muscle forces and joint activations required for execution.

From the previous, it could be concluded that the type of motor responses depends basically on the performance level of the related sensory systems (quality of sensory information and speed of delivering them to the brain) and of the cognitive system (speed and quality of the central processing). Additionally, the speed and quality of movements accomplished by the motor system depend basically on the performance of its parts and other helpful body parts[4].

On the level of a single motor unit, the force produced by a single motor unit is determined by the type and number of muscle fibers in the unit, and by the rate at which the nerve impulses arrive at the motor unit fibers – known as the motor unit firing rate (De Luca C.: 1985). It may vary from frequencies low enough to produce a series of single twitch contractions to frequencies high enough to produce a fused tetanic contraction (ibid.). If impulses are delivered slowly enough, the tension in the muscle will relax among successive twitches; if impulses are delivered at high frequency, the twitches will overlap, resulting in tetanic contraction, in which a motor unit stays fully contracted, under voluntary control, until the mind decides to relax it (Wikipedia: Tetanic contraction). It can exist in a variety of states, e.g. lifting a heavy box off the floor, and holding it at an elevated position (ibid.). Generally, this allows a 2 to 4-fold change in force; in general, the motor unit firing rate of each motor unit increases with increasing muscular effort until a maximum rate is reached (De Luca C.: 1985). Thus, the brain has 2 distinct ways of controlling the force produced by a muscle through motor unit recruitment: spatial and temporal recruitment; spatial recruitment is the activation of more motor units to produce a greater force, and temporal motor unit recruitment deals with the frequency of activation of muscle fiber contractions (Wikipedia: Motor unit).

[1] It's a general mental function. See the cognitive system – section 6.3.3.

[2] External stimuli, such as visual, auditory, olfactory, gustatory and tactile ones (WHO: 2001, p. 55, 56); and internal stimuli, such as pain, hunger and the positions of the parts of the body.

[3] Between the processes of perception and response selection, many different cognitive functions are activated according to the required task to be performed; such as attention, memory, the mental function of language, calculation and intelligence.

[4] For example, the execution of many movements requires good eyesight.

Aspects of motion:

Because the motor system consists of many interacting parts at many different organizational levels (Wikipedia: Motor Control), evaluating the performance of an individual's motor system (speed and quality of execution) – the function of motion – is via evaluating many movement-related aspects or sub-functions which express the performance level of the motor system structures singly and collectively. Generally, those aspects are outlined in:

- **Structural support:** It refers to the range and ease of support provided by bones during performing movements.
- **Range and ease of movement (flexibility):** It refers to the absolute range of movement in a joint or series of joints, and muscles' length that crosses the joints to induce a bending movement or motion (Wikipedia: Flexibility). Quality of flexibility depends basically on joint characteristics (incl. tight ligaments and tendons, amounts of cartilage, and the consistency or amounts of synovial fluid) controlling the length of muscles around the joints; muscle composition controlling the magnitude of force outputs; and activation characteristics (process characteristics) controlling the magnitude, form and speed of force outputs (Ketcham, C.: 2004). Putting on socks or stockings, safely pulling out into traffic, and picking up a dropped object, are tasks of daily living requiring flexibility to be successfully completed (ibid.)
- **Range of force production:** It's the range of force generated by the contraction of all muscle fibers of a muscle (WHO: 2001, p. 96), whatever the contraction type: single twitch, successive twitches or fused titanic contraction. It depends basically on the muscle composition (type and number of muscle fibers).
- **Range of muscle endurance:** It's the range of sustaining muscle contraction for the required time (WHO: 2001, p. 98), whatever the contraction type: single twitch, successive twitches or fused titanic contraction. It depends basically on the muscle composition (type and number of muscle fibers).
- **Acceleration/deceleration ratio:** A movement trajectory is decomposed into acceleration and decaleration phases (Ketcham, C.: 2004). The acceleration/deceleration ratio expresses the portion of acceleration and deceleration phases of the whole movement.
- **Peak velocity:** It's the point at which the change of the direction of the movement speed occurs – transferring from the acceleration phase to the deceleration phase.
- **Movement duration – MT:** It's defined as the time from the initiation of the movement to the termination of the movement (ibid.). It's the total time of acceleration and deceleration phases of the movement.

- **Speed and accuracy:** As individuals attempt to do a movement faster, there's a point where the response accuracy is compromised (ibid.). Individuals, based on their ability, often have different speed-accuracy behavioural patterns (ibid.). Here, what is the speed at which the accuracy of a movement is negatively affected?

- **Movement variability:** It refers to an individual's overall consistency of an executed task across trials. Increased variability may reflect decrements in the motor system in its ability to produce the same movement output repeatedly. There are 2 types of movement variability: variability of the endpoint and variability of the components of the movement trajectory (movement duration, peak velocity, and the acceleration/deceleration ratio). (ibid.)

- **Force control and regulation:** Force control is an elementary component of movement production, e.g. smooth and accurate movements require efficient modulation of force outputs (ibid.). The ability to control and modulate the forces an individual applies depends basically on activation characteristics controlling the magnitude, form and speed of force outputs. The brain can control the strength of each muscle by determining how many motor units (thus the number of muscle fibers) to activate (InnerBody: Muscular System), and the frequency of activation of such motor units for a given function. Problems in the regulation of force outputs lead to problems in the initiation and control of movements, in turn, they have large implications for most functional tasks – e.g. turning a door knob or picking up a glass of liquid (Ketcham, C.: 2004).

- **Coordination:** It refers to performing movements in an orderly combination (WHO: 2001, p. 100). It's the ability to control some movement segments or body parts in a refined manner resulting in a well -timed motor output; e.g. in reach-to-grasp tasks, there are transport and grasp components that must be coordinated both spatially and temporally (Ketcham, C.: 2004). Coordination is a part of most tasks of daily living and therefore it's essential to understand breakdowns in control and regulation (ibid.). Coordination is directed by the brain but is affected by the state of the other parts of the motor system.

- **Posture control:** Posture is the position of an individual's body. Posture control is the ability to stabilize a posture for performing a specific task. Most skilled movements involve posture in some manner, because there needs to be a stable base of support to perform motor skills such as pointing, reaching, and grasping (ibid). The ability to stabilize posture is important for a variety of movements required for functional tasks of daily living; postural stability is commonly measured during quiet stances or following platform perturbations (ibid). A body posture is basically related to type I muscle fibers being very resistant to fatigue and suitable for stamina and posture (InnerBody: Muscular System). Also, the body posture is affected by the state of the other parts of the motor system.

- **Proprioception**: It's a term used to denote the sense of how body segments are oriented in relation to each other. It depends on receptors in the joints, tendons and muscles; and their connected proprioceptive neurons. To produce smoothly controlled and regulated movements, the central nervous system must be able to accurately identify movement onsets and determine the exact location of the limb at any given time (sense the positions of the relative parts of the body and the strength of effort being employed in movement). A reduced capability to accurately detect the position of the limb has large implications for movement control; making it difficult to produce rapid, well-coordinated movements. (Ketcham, C.: 2004) – See also, Bassett, S.: 2012; MedTerms medical dictionary: Proprioception; and Wikipedia: Proprioception & Sense.

Briefly, all the above-mentioned movement-related aspects or sub-functions form together motion – the function of the motor system. With the fact that the motor system covers many different movements according to the body part being in action, the motion takes many forms. For this part of the study concerning the physical interaction between people and designed things – the using phase – 3 main forms of motion are of particular relevance: locomotion, reach & stretch and dexterity. They are defined in the following (Waller, S.):

- **Locomotion:** It's 'the ability to move around, bend down, climb steps, and shift the body between standing, sitting and kneeling'.
- **Reach & stretch:** It's 'the ability to put one or both arms out in front of the body, above the head, or behind the back'.
- **Dexterity:** It's 'the ability of one or both hands to perform fine finger manipulation, pick up and carry objects, or grasp and squeeze objects'.

6.4. Appendix: Ageing and the human body abilities

6.4.1. Ageing and vision:

Progressive visual impairment is one of the most clear-cut areas of decline in older adults (Hawthorn, D.: 2000, p. 509). Sight loss affects people of all ages, but as we get older we are increasingly likely to experience sight loss (Royal National Institute for the Blind). While there are 2 million people with poor or no vision in the UK (approx. one person in 30) (ibid.), 90% are over 60 years of age (Kurniawan, S.: 2009, p. 8-2). Also, approx. 20% of people aged 75+ and 50% of people aged 90+ in the UK are living with sight loss (Royal National Institute for the Blind). For Americans, 19% of people aged 70+ had visual impairments; nearly 92% of those over 70 years of age wore eyeglasses; difficulty in seeing even when wearing eyeglasses increased from 14% among persons 70: 79 years of age to 32% for those 85 years of age or older; and 18% relied upon hand-held magnifiers for reading and related visually guided activities (Desai, M.: 2001). Actually, older adults show a reduced ability in most visual functions. This is briefly stated in the following[1]:

- **Visual acuity:** Studies of age-related differences reveal that older adults usually experience a significant decline in visual acuity, which can be attributed to several causes such as:

  With ageing, errors in how the light is refracted in the eyeball are a common condition. It's another type of refractive error, known as presbyopia. It's an age-related disorder where the eyes exhibit a progressively diminished ability to focus on objects or detail at close distances (Kurniawan, S.: 2009, p. 8-3); it's caused by the gradual lack of flexibility in the crystalline lens of the eye due to the natural ageing process – the crystalline lens becomes less capable of bending as we grow older[2] (St. Luke's Cataract & Laser Institute: Presbyopia and Schieber, F.: 2003, p. 45). By the mid-forties, people begin to have difficulty focusing upon printed texts that are closer than arms length in distance (Atchison, D.: 1994) and by 60 years of age, the ability to focus upon objects within a range of 3 feet has all but vanished (Schieber, F.: 2003, p. 45). Presbyopia isn't 'a disease and cannot be avoided; however, it can easily be corrected with lenses or eye surgery. People with presbyopia usually have a diminished visual field and tend to compensate for this by moving their head from side to side when reading instead of sweeping their eyes from left to right' (Kurniawan, S.: 2009, p. 8-3).

  Another common cause of low visual acuity among older adults is the deterioration of the retina. There's some evidence of photoreceptor and ganglion cell loss with advancing age (Curcio, C.A.: 1993 and Youdelis, C.: 1986). Curcio, C.A. et al. (1993) reported that nearly 30% of the rods in the central 30

[1] For more details, see Schieber, F. (2003), Kline, D. W. (1997) and Hawthorn, D. (2000).

[2] Despite its symptoms, presbyopia isn't related to nearsightedness, which is due to an abnormality in the shape of the eye. (Kurniawan, S.: 2009, p. 8-3)

degrees of vision are lost by 90 years of age. The prevalence of retinal diseases that impair visual function increases remarkably with advancing age (Schieber, F.: 2003, p. 43).The impaired visual acuity observed among those in the 70+ age group is primarily the result of the increased prevalence of diseases of the retina; even the best available eyeglasses can't compensate for pathological deterioration of the retina and related neural structures (ibid., p. 45). One of these diseases is Age -Related Macular Degeneration (AMD). It's a genetic disease and the most common cause of severe visual impairment among older people (Ford, M.: 1993). It refers to the breakdown or thinning of the most sensitive cells of the eye clustered in a small area in the centre of the retina known as the macula (Zarbin, M.: 1998), which is responsible for clear vision. The macular disease causes progressive loss of central vision; sufferers still can see adequately at the peripherals of their vision (Ford, M.: 1993). While never resulting in total blindness, AMD is often severe enough for the sufferer to be classed as partially sighted or blind (Kurniawan, S.: 2009, p. 8-3). Symptoms of the macular disease usually start around the early to mid-fifties, typically starting in just one eye (ibid.). Noticeable degrees of macular degeneration afflict 18% of persons 70: 74 years of age and more than 47% among those over 85 years of age (Schieber, F.: 2003, p. 43).

Furthermore, reduction of retinal illumination is a common condition among older adults; which in turn, negatively affects visual acuity. Weale, R. (1961) has estimated that only one-third of the light reaching the retina of a 20-year-old will reach that of a 70-year-old. One common reason for this is the decline of transparency of the crystalline lens of the eye. The lens is responsible for focusing light coming into the eye onto the retina to produce clear and sharp images; when the lens of the eye becomes clouded, the eye is no longer able to adequately process light coming into the eye (Kurniawan, S.: 2009, p. 8-3). The crystalline lens of the eye becomes increasingly opaque as individuals grow older. This loss of transparency appears to be particularly pronounced at short wavelengths (Said, F.: 1959); which means that less violet light enters or can reach the retina, making it harder to see colours like blue, green, and violet compared with reds, oranges, and yellows (AgeLight LLC: 2001). Half of those over 65 years of age suffer from lenticular opacity that is severe enough to be classified as cataract (Schieber, F.: 2003, p. 43). Cataract refers to the loss of transparency, or clouding, of the lens of the eye and is predominantly an age-related disease (Spector, A.: 1982). It's caused by an accumulation of dead cells within the lens; and it's the most common cause of vision loss among people aged 55+ (St. Luke's Cataract & Laser Institute: Cataract).

- **Visual field:** Shrinking of the visual field is more common among older adults; 'loss in visual acuity associated with increased eccentricity away from the point of fixation appears to be more dramatic among older observers' (Schieber, F.: 2003, p. 47). This means a reduction in the useful field of acuity (ibid.) or the width of the visual field (Kurniawan, S.: 2009, p. 8-2), a condition referred to as tunnel vision at the more severe state (Cerella, J.: 1985). One of its common causes is glaucoma. 'Glaucoma is a group of diseases that can damage the optic nerve and cause blindness. While not a direct age-related disorder, it most commonly affects people over 60 or African Americans over 40 years old' (Kurniawan, S.: 2009, p. 8-3).

- **Colour vision:** Most people's ability to distinguish colours declines with age; it's a natural part of the ageing process (NHS choices); mainly because of cataract – clouding and yellowing of the eye lens (NEI). Small but systematic age-related declines in the ability to distinguish between similar hues and colour combinations with low contrast have been demonstrated in numerous studies (Schieber, F.: 2003, p. 48) – especially in the blue-green range (Helve, J.: 1972), and under low light conditions (Schieber, F.: 2003, p. 48). Older persons with colour blindness normally have worsened conditions with age, due to decreased blood supply to the retina (AgeLight LLC: 2001).
- **Contrast sensitivity:** Studies of age-related differences reveal that older persons usually experience a significant decline in contrast sensitivity (Owsley, C.: 1983 and Sia, D.: 2013); they need higher levels of contrast among static objects than their younger counterparts to detect these objects. Shrinking of the pupil is the cause of this decline, whereas the pupil is less able to change diameter, therefore letting in less light (Kurniawan, S.: 2009, p. 8-2).
- **Disability glare:** Older adults are more sensitive to glare and less able to adapt to rapid shifts in brightness – they need more time to recover their lost visual sensitivity (Hawthorn, D.: 2000, p. 509).
- **Dark adaptation:** Light sensitivity of older adults is significantly worse than their young counterparts at all phases of the dark adaptation cycle – especially in short-wavelength light (i.e. blue, green) due to age-related yellowing of the lens (Schieber, F.: 2003, p. 44).[1]

[1] So, this requires that emergency lighting and guidance systems should use broadband or long-wavelength illuminaire and specify intensity levels that meet the needs of the older eye. (Schieber, F.: 2003, p. 44)

6.4.2. Ageing and hearing:

Hearing ability declines with age (Hawthorn, D.: 2000, p. 511) – decline in auditory functions (such as the decline in sound detection, sound discrimination, speech discrimination, sound source localization, or sound source discrimination). In adults, the most common causes of gradual hearing loss[1] are noise and ageing; there's a strong relationship between age and reported hearing loss (Hearing Loss Association of America: Basic Facts about hearing loss); it's a common condition among older adults and it progresses rapidly in most patients over the age of 75 years (Turner, J. and Per-Lee, J.: 1990). Figures have indicated that approx. 2% of American adults aged 45 to 54 have disabling hearing loss; the rate increases to 8.5% for adults aged 55 to 64; and nearly 25% of those aged 65 to 74 and 50% of those who are 75 and older have disabling hearing loss (NIDCD: 2014, Quick Statistics). According to data reported in 1999, although those aged 65 years or more formed only 12% of the general American population, 43% of American people with hearing loss are 65 years of age or older (National academy on an aging society: 1999).

Older adults show a reduced ability to localize sound sources and this is more pronounced in individuals with presbycusis (Kline, D.: 1997) – see the next paragraph – and a loss of the ability to follow conversations in noisy surroundings (Hawthorn, D.: 2000, p. 511). They also hear comfortably at louder sound; in a study, Coren, S. (1994) found that while 25-year-old adults had a median hearing comfort level at 57 dB, 75-year-old adults had a median hearing comfort level at 79 dB. Also, older adults show a decreased ability to detect tones over all frequencies, but especially high-pitched (high -frequency) sounds (Schieber, F.: 1992). The loss of sensitivity to frequencies with increasing age is much greater at high than at low frequencies (Kinzel, E.: 2009, p. 6-7). While the spectral-frequency band in which the ear can detect tones in quiet extends from about 20 to 20000 Hz – at least for a young and normal-hearing person (Dobie, R.: 2004, p. 48) – older adults often miss attention-getting sounds with peaks over 2500 Hz, making them susceptible to not noticing the sound of fire alarms, telephone bells and smoke alarms tend to have intensity peaks around 4000 Hz (Berkowitz, J.: 1990 and Huey, R.: 1994).

One of the most common conditions affecting older adults is 'age-related hearing loss' (presbycusis)[2] (Dobie, R.: 2004, p. 60, 61); it's the loss of hearing that gradually occurs in most of us as we grow/get older; and it most often occurs in both ears, affecting them equally (NIDCD: 2014, Age-related hearing loss). It causes a slow but steady hearing loss; which may be mild or severe, and is always permanent (Hearing Loss Association of America: *Basic Facts about hearing loss*). There are many causes of presbycusis.

[1] Gradual hearing loss is different from congenital hearing loss, while gradual hearing loss happens over time, congenital hearing loss means you are born without hearing (Hearing Loss Association of America: Basic Facts about hearing loss).

[2] Hearing loss that accumulates with age but is caused by factors other than normal ageing isn't presbycusis.

'Most commonly, it arises from changes in the inner ear as we age[1], but it can also result from changes in the middle ear[2], or from complex changes along the nerve pathways from the ear to the brain' (NIDCD: 2014, Age-related hearing loss). Other conditions that are more common in older people, such as high blood pressure, diabetes, or the use of certain medications that are toxic to the sensory cells in the ears (e. g. some chemotherapy drugs) can further contribute to hearing loss (ibid.).

6.4.3. Ageing and cognition:

There's overwhelming evidence that ageing in normal adults is accompanied by declines in most cognitive functions. This was reported in numerous studies – the following confirms this. Some aspects of age-related cognitive decline begin in healthy educated adults when they are in their 20s and 30s (Salthouse, T.: 2009). The age-related declines in cognitive functions are briefly outlined as follows:

- **Perception:** Regarding visual perception, numerous studies have demonstrated age-related decrements in several of a person's abilities to make sense of what is seen (Hawthorn, D.: 2000, p. 510); e.g, the ability to recognize figures that are embedded within other figures (Capitani, E.: 1988), ability to recognize objects that are fragmented or incomplete (Salthouse, T.: 1988 and Frazier, L.: 1992) and ability to locate a target figure in a field of distracters (Plude, D.: 1981; Ellis, R.: 1996 and Hess, S.: 1999). This is because reduced ability to suppress these distracters from the focus of attention (Hawthorn, D.: 2000, p. 510). Furthermore, in a study, examining age-related changes in participants' ability to perceive global spatial structure defined by temporal fine structure among elements undergoing rapid and irregular change, older individuals – compared with young adults – were less sensitive to spatial form defined by temporal structure (Blake, R.: 2008). Additionally, other studies[3] have demonstrated age-related decrements in motion sensitivity and the accuracy of speed perception (motion perception) (Schieber, F.: 2003, p. 47); e.g. detecting the minimal motion of objects by the elderly (Hawthorn, D.: 2000, p. 509), and the ability to judge the apparent speed of automobiles (Schieber, F.: 2003, p. 47).
- **Attention**: Vercruyssen, M. states that older adults have problems maintaining attention on activities over long periods and suggests that tasks requiring rapid or continuous scanning are particularly

[1] So it's classified as SNHL (Hearing Loss Association of America: Types, Causes and Treatment).

[2] Rarely, age-related hearing loss can be caused by abnormalities of the outer ear or middle ear. Such abnormalities may include reduced function of the tympanic membrane (the eardrum) or reduced function of the 3 tiny bones in the middle ear that carry sound waves from the tympanic membrane to the inner ear. (NIDCD: 2014, Age-related hearing loss)

[3] See Schieber, Frank (2003) and Kline, D. W. (1997) for reviews confirming these findings.

fatiguing for older adults (Vercruyssen, M.: 1997). Other studies state that the ability to pay attention to relevant information in the presence of distracting information (selective attention tasks) declines with age, (Connelly, S.: 1993 and Kotary, L.: 1995). Besides, it's reported that the ability to attend simultaneously to and process more than one task at the same time (divided attention) declines with age, particularly in complex tasks rather than simple or nearly automatic tasks (McDowd, J.: 1988 and Hartley, A.: 1992).[1]

- **Memory:** Excluding pathological conditions such as Alzheimer's disease, normal ageing always negatively affects the different forms of memory (short-term, long-term and working memory) (Hawthorn, D.: 2000, p. 517) due to the decrease in the speed of information being encoded, stored, and received (Wikipedia: Old age). There's a general agreement that memory performance declines from early to late adulthood, and that such age-related declines are much greater in relation to some tasks than in others (Grady, C.: 2000). Studies have found a decline in many types of memory with ageing, but not in semantic memory which doesn't decline until very late in life. See Howard, J. (1997) and Smith, A. (1996) for reviews and Schieber, F. (2003) for more details.

  With regards to short-term memory, the amount of information that can be held in short-term memory before being forgotten is less for older adults than for younger adults (Kausler, D.: 1994, p. 149: 173). Botwinick, J. and Storandt, M. (1974) found that the number of items that can be held in short-term memory averages around 6.5 items for people in their 20s to 50s, but this number drops to around 5.5 for those in their 60s and 70s.

  With regards to long-term memory, Howard, J. and Howard, D. (1997) state that findings of age -related deficits in episodic memory (memory for specific events) and procedural memory (memory for how we carry out tasks) are common, but there's generally little age-related decline in semantic memory (memory which holds information about the meaning of the components of one's world) until extreme old age. (Hawthorn, D.: 2000, p. 517) 'As people grow older, the capacity to move information from short-term to long-term memory is also decreased. This could explain why some (not all) older people may require repeated relearning of concepts in technology use before they can independently use a system.' (Ashok, M.: 2009, p. 4-7)

  With regards to working memory, there's 'overwhelming evidence that normal adult ageing is accompanied by a working memory deficit' (Schieber, F.: 2003, p. 64); it's among the cognitive functions most sensitive to decline in old age; numerous studies have reported that (e.g. Wingfield, A., 1988 and Dobbs, A.: 1987). Howard, J. and Howard, D. (1997) suggest that 'we will only see effects with age when tasks impose significant load on working memory'. With this, the changes appear to be in how people encode and retrieve information (American Psychological Association). Tests of working

[1] See Schieber, Frank (2003) for reviews confirming these findings, pp. 54: 62.

memory show that there's a stronger decline in the ability to process items in short-term memory as distinct from simply recalling them (Dobbs, A.: 1989 and Salthouse, T.: 1994) and processing of visual information in short-term memory also slows with age (Hoyer, W.: 1992). Light, L. (1990) suggested that working memory decline underlies older people's problems in text comprehension.

Also, Ratner, H. et al. (1987) state that older adults show significant declines in the ability to recall content, but little declines in the ability to perform on memory tasks simply involving recognition that some items are familiar from previous exposure. Older adults tend to have poorer memory for non-verbal items such as faces (Crooke, T.: 1992); spatial memory tasks, for example remembering which quadrant a word appeared in (Denny, N.: 1992), replacing items correctly in a model (Cherry, K.: 1993), or map routes (Lipman, P.: 1992). Cited from (Hawthorn, D.: 2000, p. 517, 518)

- **Intelligence**: Studies on changes in cognition with age suggest that there's some decline in intellectual performance with ageing (Schaie, K.: 1996 and Zajicek, M.: 2001). Depending on longitudinal data from a large set of studies by Schaie, K. (1989, 1996), Hawthorn, D. (2000) acknowledges that decline in reasoning ability of individuals begins after their mid-60s, while they show steady reasoning ability throughout most of their lifespan (Hawthorn, D.: 2000, p. 520). Some studies indicate that intellectual ability decline is likely to be evident only in tasks that are complex and require activation of an individual's reserve capacities (Schaie, K.: 1996 and Baltes, P.: 1982). Schaie, K. (1996) suggests that a major decline in intellectual abilities is probably mainly in abilities that weren't central to the individual's life experience and were limited to late old age. This agrees with Horn, J.'s attempts (1982) to divide intelligence into crystallized intelligence which is based on life experience and cultural knowledge, and fluid intelligence which measures skills of perception and abstract reasoning which aren't directly incorporated in experience but are more directly related to the integrity of the central nervous system (Horn, J.: 1982). His studies show that there are gains in crystallized intelligence up to the sixties in comparison to losses of fluid intelligence (Horn, J.: 1970, 1982 and Horn, J.: 1976).

  It's suggested that intellectual performance would decline more slowly in individuals with high levels of education (Schaie, K.: 1989) and that high job status and work complexity are positive predictors of maintaining cognitive functioning into old age (Miller, J. et al.: 1987 in: Schaie, K.: 1996, p. 278).

- **Automated response:** The ability of most older adults to form new automated responses becomes more difficult; while older adults are able to learn new responses, they continue to remain attention demanding, which contributes to cognitive load (Rogers, W.: 1994); and where older adults do possess automated responses, these can become disruptive when learning new tasks, because it is difficult to unlearn responses where the person is unconscious of the response (Rogers, W.: 1991). Cited from (Kurniawan, S.: 2009, p. 8-4 and Hawthorn, D.: 2000, p. 516)

All previous age-related declines in cognitive functions negatively affect the processing speed (expressed by RT) which results in longer overall task completion time (response time). Collectively, the literature on response speed (expressed by response time) documents delayed initiation of a behavioural response (increasing RT) in older adults compared with young adults across an array of simple and complex tasks[1] (Ketcham, C.: 2004). Studies have shown that most of the response delays in older adults are accounted for in the premotor or cognitive period (ibid.). Effects of age-related slowing in cognitive processing have been subjected to 2 streams of conflicting theories over the nature of slowing (Sliwinski, M.: 1998). The first is general slowing theories stating that as people age, there's a general overall slowing of cognitive processing speed and it's independent of task-specific cognitive requirements (Groth, K.: 2000). The second is task-related slowing theories stating that age results in differential rates of slowing depending on the task or processing domain (Kurniawan, S.: 2009, p. 8-3). Sharit, J. and Czaja, S. (1994) state that age effects are smallest for tasks where knowledge is an important aspect of the task, and largest for tasks where successful performance is primarily dependent on processing speed that require the most cognitive processing (working memory, overall attention capacity and visual search performance).

Furthermore, older adults show greater susceptibility to diseases that affect negatively their cognitive system, thus their cognitive abilities. The most common are Alzheimer's disease and Dementia. Alzheimer's disease is a progressive, degenerative disorder that attacks the brain's nerve cells, or neurons, resulting in loss of memory – remembering recent events (short-term memory loss), thinking and language skills, and behavioural changes (AFA). It most often begins in people over 65 years of age and affects about 6% of people 65 years and older (Wikipedia: Alzheimer's disease). Regarding dementia, it 'is a syndrome in which there is deterioration in memory, thinking, behaviour and the ability to perform everyday activities' (WHO: 2015, Dementia). 'Although dementia mainly affects older people, it is not a normal part of ageing' (ibid.). Between 5 to 8% of the general population aged 60 and over at a given time have dementia (ibid.). In the USA, about 3% of people between the ages of 65 and 74, 18.7% between 75 and 84 and 47% of those over 85 years of age have dementia (Schulte, O.: 2013, p. 838). Alzheimer's disease is the most common cause of dementia and may contribute to 60: 70% of cases (WHO: 2015, Dementia).

With all the above-mentioned age-related differences in sensory and cognitive abilities, the communication ability of older adults is easily negatively impacted. The decline in hearing, vision and cognitive abilities in older adults, simply leads to a decreased ability to understand other people and to express oneself, which can cause communication barriers.

[1] In studies with older adults, response times increase significantly with more complex motor tasks (Spiriduso, W.: 1995) or in tasks with a larger number of choices (Hawthorn, D.: 2000, p.513).

6.4.4. Ageing and motion:

Studies on age-related differences in the motor system found that older people experience more problems in performing motor actions than their younger counterparts do. Anatomical and physiological changes in the motor system[1] components are common with ageing; mostly, they negatively affect the motor performance of older adults outputting weak, slow, limited and more variable movements[2] (Ketcham, C.: 2004). This in turn, negatively affects the successful performance of tasks of daily life. A review by Ketcham, C. and Stelmach, G. (2004) and a wide-ranging review by Vercruyssen, M. (1997) document many of the major changes that occur in aspects related to movement with respect to ageing, especially those related to the control and coordination of a movement. The following informs us briefly about age-related declines in many aspects related to movement and mobility function.

- **Structural support**: It's concerned with support provided by the bones. With ageing; bone mass or density is lost, especially in women after menopause, the bones lose calcium and other minerals making each bone thinner and more brittle – reaching to osteoporosis – and may break more easily[3]; the middle of the spine (trunk) becomes shorter as the disks (a gel-like cushion among vertebras) gradually lose fluid and become thinner; the spinal column becomes curved and compressed (packed together) resulting in a loss of height and a stooping posture in many people; bone spurs, caused by ageing and overall use of the spine, may also form on the vertebrae; the foot arches become less pronounced, contributing to a slight loss of height; and overall height decreases, mainly because of shortening of the trunk and spine (MedlinePlus: Aging changes ...). These degenerative changes in the bones characteristics of older adults, negatively affect the range and ease of movements required for tasks of daily life.
- **Flexibility:** Changes in joint characteristics, muscle composition and activation characteristics, as well as higher levels of disuse in older adults, lead to overall decreases in flexibility in older adults (Ketcham, C.: 2004). With ageing, the joints become stiffer and less flexible; the synovial fluid in the joints may decrease, and the cartilage may begin to rub together and erode; minerals may deposit in and around some joints (calcification); the hip, knee and finger joints may begin to lose joint cartilage surface (degenerative changes) leading to osteoarthritic changes common in older adults; and inflammation, pain and stiffness – reaching to severe arthritis – and deformity may result from a break-

[1] For more related information, see the motor system – section 6.3.4.

[2] Movement slows and may become limited; e.g. the walking pattern (gait) becomes slower and shorter (MedlinePlus: Aging changes ….).

[3] With old bones, many are more susceptible to falls. Every year, about one-third of those 65 years old fall (Tromp A.: 2001). Falls are the leading cause of injury and death for old people (CDC).

down of the joint structures (MedlinePlus: Aging changes ….). With advanced age, the length of muscles around the joints is reduced as a result of lower flexibility of joint structures resulting from changes in the hydration and microstructure of collagen within the joint (Ketcham, C.: 2004). However, older adults show a substantial loss in the range and ease of motion of their joints – thus the range and ease of movements – due to the anatomical changes in joint structures (ibid.).

Regarding muscle composition, it has been shown that the number and size of muscle fibers decrease in older adults – loss of muscle tissue and mass – with the most substantial decrease occurring in fast-twitch fibers (approx. 40% of fast-twitch muscle fibers are lost) (ibid.). Lipofuscin (an age-related pigment) and fat are deposited in muscle tissue (MedlinePlus: Aging changes ….). Furthermore, muscle tissue is replaced more slowly, and lost muscle tissue may be replaced with a tough fibrous tissue; this is most noticeable in the hands, which may appear thin and bony (ibid.)**.** The loss of muscle mass in older adults leads to overall decreases in the magnitude of force production (Ketcham, C.: 2004).

Regarding activation characteristics**,** with ageing, 'the existing motor units are reorganized to include more muscle fibers per innervation and subsequently change the way force outputs are achieved' (ibid.). Activation of muscle is more bursty and less smooth than in young adults, resulting in force outputs of large incremental steps – lower control in force outputs; moreover, the contractile speed of muscles in older adults is slower than in young adults, which also influences the ability to ramp forces in any given muscle – decrease the control in force outputs (ibid.). Also, these changes in the magnitude of force outputs and the ability to control and modulate the forces an individual applies (magnitude, form and speed of force outputs) negatively affect the range and ease of movements (flexibility).

The previous age-related changes lead to overall decreases in flexibility and can restrict relative movements (ibid.). Decreased flexibility has implications for tasks of daily living as it often determines whether a task, like putting on socks or stockings, safely pulling out into traffic, or picking up a dropped object, can be successfully completed (ibid.).

- **Range of force production:** Older adults compared with young adults have decreased force outputs – a reduced range of force production – which negatively affects the control and coordination of movements and makes it difficult to initiate and execute movements quickly and accurately across a variety of tasks (Ketcham, C.: 2004). It has been reported that older adults have lower peak force output and a longer time for force production than young adults (ibid.). Such differences may be a result of muscle composition changes – see flexibility. Changes in the muscle tissue lead to overall decreases in the magnitude of force production (ibid.)**.** Degenerative changes in the muscle tissue, combined with normal ageing changes in the nervous system, cause muscles to have a reduced ability to contract (MedlinePlus: Aging changes ….). In turn, muscle weakness contributes to fatigue, weakness, and reduced activity tolerance (ibid.).

- **Acceleration/deceleration ratio:** It has been shown that the velocity profiles of young adults are typically bell-shaped, where the acceleration phase equals the deceleration phase; and velocity profiles of older adults are asymmetrical with a longer deceleration phase (Ketcham, C.: 2004).

- **Peak velocity**: Older adults produce movements with 30: 70% lower peak velocity compared with young adults. (ibid.)

- **Movement duration -MT:** MT is increased in older adults for a variety of tasks including, point-to -point movements, reaching and grasping movements, handwriting, and continuous movements (ibid.). Movement durations are longer in older adults compared with young adults in tasks ranging from simple to complex (ibid.). With the fact that as the difficulty of the movement increases, the speed of the movement decreases; research has shown that older adults tend to move slower than young adults at all levels of difficulty (ibid.). Some authors have speculated that these increases are caused by the reduced ability of older adults to produce and maintain forces across the entire spectrum of the movement (ibid.). Furthermore, it has been shown that increasing MT occurs in both acceleration and deceleration phases of a movement; e.g. the deceleration phase in older adults is in the range of 20: 40% longer than that of young adults (ibid.).

- **Speed and Accuracy:** Older adults need more time to complete a task when they perform with accuracy levels similar to young adults. In other words, to achieve the same response accuracy, older adults perform with less speed. One common observation of investigators, who have made cross -sectional comparisons, is that older adults have a bias for accuracy at the expense of speed. Older adults are often more conservative with respect to speed than young adults. The question arises as to whether such differences are caused by changes in the neurophysiological factors causing declines in RT and MT, or by additional different cognitive strategies through slowing down purposely their movements to ensure that they are made with a high level of accuracy. When an individual trades response speed for response accuracy, it's an example of the influence of cognitive processes on motor performance. Such cognitive strategies make it difficult to accurately determine the amount of change that is due to neurophysiological factors. (Ketcham, C.: 2004 and Kurniawan, S.: 2009, p. 8-5)

- **Movement Variability:** Over a wide variety of tasks, researchers report higher variability in the end -point position and the components of the trajectory of movements of older adults compared with young adults. Increased variability may reflect decrements in the motor system ability to produce the same movement output repeatedly. For example, if the motor system is quite variable, it's difficult to know whether you may knock over a glass when you reach for it. It's documented that older adults had higher end-point variability than young adults and that their end-point variability improved but not as much as young adults after extended practice for both of them. Also, it's documented that older adults were significantly more variable compared with young adults on measures including movement duration, peak velocity, and the acceleration/deceleration ratio forming the movement trajectory profile. (Ketcham, C.: 2004)

- **Force control and regulation:** It has been reported that older adults compared with young adults have 'less ability to control and modulate the forces they apply' (Siedler, R.: 1996) – inefficient force regulation/lower control in force outputs – making it difficult to initiate and execute movements quickly and accurately across a variety of tasks (Ketcham, C.: 2004). This is consistent with a study reporting that handwriting quality declines in older people (Dixon, R.: 1993). It has been shown that older adults produce multiple bursts of force in tasks when they must achieve targeted force levels approaching maximum, this is in contrast to young adults who produce a single burst to the targeted force level (Ketcham, C.: 2004). Older adults have higher force output variability compared with young adults (ibid.). Such differences may be a result of changes in activation characteristics controlling the magnitude, form and speed of force outputs – see flexibility.

- **Coordination:** The ability to control multiple movement components at any one particular time becomes increasingly difficult with advanced age across a variety of movements including aiming, reaching and grasping, drawing, handwriting, and bimanual coordination tasks (ibid.). Overall, it has been shown that older adults have increased difficulty controlling and regulating multiple segments or body parts to produce smooth motor outputs (ibid.). Additionally, they may have difficulty in receiving new information during the execution of movements (Hawthorn, D.: 2000, p. 513, 514).

- **Posture control:** Typically, older adults have more body sway with all testing conditions of posture control (Hageman, P.: 1995); they have been shown to have deficits in postural control mechanisms during both quiet stance and perturbation-induced sway balance tests (Ketcham, C.: 2004). Additionally, to recover from perturbation, older adults take longer to initiate corrective or protective actions than young adults; these delays greatly increase the risk of falling as the time to prevent destabilization is quite short (ibid). Overall, data on balance and postural stability in older adults document that older adults show declines in the ability to maintain postural stability and recover from disturbances (ibid). These decrements greatly contribute to instability and influence functional tasks of daily life (ibid).

- **Proprioception**: It has been reported that older adults have decreased proprioceptive capabilities (Ketcham, C.: 2004); older people are less accurate in reporting body position in relation to surroundings (Vercruyssen, M.: 1997). The reduced ability in older adults to accurately detect movement or localize a body segment position has large implications for movement control and makes it difficult to produce rapid, well-coordinated movements (Ketcham, C.: 2004). This has major functional implications for older adults in a variety of tasks of daily life, from sitting in a chair to reaching for an object (ibid.).

Moreover, older adults show greater susceptibility to age-related diseases that negatively affect structures and functions of their body motor system, which affect their motor abilities to do tasks (motor performance). Most common age-related diseases include MS, arthritis, osteoarthritis, osteoporosis, stroke, and Parkinson's disease. According to their symptoms – see p. 68 – any of these diseases can severely affect older persons' motor abilities (Kurniawan, S.: 2009, p. 8-5). With these diseases, older adults show poorer performance while carrying out many tasks.

Overall, age-related declines in sensory, cognitive and motor abilities increase the older adult's response time, which may negatively affect doing tasks. At best, tasks require a longer time to be done; at worst, older adults are vulnerable during performing tasks. Vercruyssen, M. reported that older workers in machine-paced jobs have higher accident rates and fail to produce responses with sufficient speed (Vercruyssen, M.: 1997, p 70, 71). Hawthorn, D. reported that older adults are less able to cope with demands for repetitive speed (Hawthorn, D.: 2000, p. 513).

7. Appendices references

7. Appendices references

AgeLight LLC: 2001, *Interface Design Guidelines for Users of All Ages*.

AFA: *About Alzheimer's Disease*. Available at:
www.alzfdn.org/AboutAlzheimers/definition.html Accessed February 15, 2015

American Psychological Association: *Memory Changes in Older Adults*. Available at:
www.apa.org/research/action/memory-changes.aspx Accessed February 15, 2015

Ashok, Mahima and **Jacko, Julie A.:** 2009, Dimensions of user diversity, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 4-1: 4-15, CRC Press, Taylor & Francis Group, Boca Raton/London/New York.

Atchison, D.A.; Capper, E.J. and **McCabe, K.L.:** 1994, Critical subjective measurement of amplitude of accommodation, in: *Optometry and Visual Science*, 71, pp. 699: 706.

Atkinson, R.C. and **Shiffrin, R.M.:** 1968, Human memory: A proposed system and its control processes, in: *The Psychology of Learning and Motivation*, vol. 2, pp. 89: 195, Academic Press, New York.

Axmacher, Nikolai; Haupt, Sven; Lenz, Sarah; Elger, Christian E. and **Fell, Juergen:** 2010, Electrophysiological signature of working and long-term memory interaction in the human hippocampus, in: *European Journal of Neuroscience*, 31 (1), pp. 101: 117.

Baltes, Paul B. and **Willis, Sherry L.:** 1982, Plasticity and enhancement of intellectual functioning in old age: Penn State's Adult Development and Enrichment Project (ADEPT), in: *Aging and Cognitive Processes*, 8, (Craik, F.I.M. and Trehub, S., eds.), pp. 353: 389, Plenum Press, New York.

Bargh, J. A.: 1992, The ecology of automaticity: Toward establishing the conditions needed to produce automatic processing effects, in: *American Journal of Psychology*, 105 (2), pp. 181: 199.

Bassett, Steven: 2012, *The Nervous System: Sensory and Motor Tracts of the Spinal Cord*, Powerpoint lecture presentation, Southeast Community College, Lincoln, Nebraska, Pearson Education, Inc. Available at:
www.napavalley.edu/people/briddell/documents/bio%20218/15_lecture_presentation.pdf

Berkowitz, J. P. and **Casali, S. P.:** 1990, Influence of age on the ability to hear telephone ringers of different spectral content, in: *The Proceedings of the Human Factors and Ergonomics Society*, 34th Annual Meeting, 8: October 12, Orlando, FL, pp. 132: 136, Santa Monica, CA: HFES.

Bernstein, Douglas A.: 2011, *Essentials of Psychology*, 5th edition, Wadsworth, Cengage Learning.

Blake, Randolph; Rizzo, Matthew and **McEvoy, Sean:** 2008, Aging and perception of visual form from temporal structure, in: *Psychology and Aging*, vol. 23 (1), pp. 181: 189. Available at: www.ncbi.nlm.nih.gov/pmc/articles/PMC2654573/

Bodine-Fowler, Sue; Garfinkel, Alan; Roy, Roland R.; and **Edgerton, V. Reggie:** 1990, Spatial distribution of muscle fibers within the territory of a motor unit, in: *Muscle and Nerve*, vol. 13, pp. 1133: 1145. Available at: http://onlinelibrary.wiley.com/doi/10.1002/mus.880131208/abstract

Botwinick, Jack and **Storandt, Martha:** 1974, *Memory, Related Functions and Age*, Charles C. Thomas, Springfield, IL.

Buchtal, F. and **Schmalbruch, H.:** 1980, Motor unit of mammalian muscle, in: *Physiological Reviews*, vol. 60, issue 1, pp. 90: 142.

Capitani, E.; Della, S.S.; Lucchelli, F.; Soave, P. and **Spinnler, H.:** 1988, Perceptual attention in aging and dementia measured by Gottschaldt's hidden figures text, in: *Journal of Gerontology: Psychological Sciences*, 43, pp. 157: 163.

CDC: *Falls among Older Adults: An Overview*. Available at: www.cdc.gov/homeandrecreationalsafety/Falls/adultfalls.html Accessed February 15, 2015

Cerella, John: 1985, Age-related decline in extrafoveal letter perception, in: *The Journal of Gerontology*, 40 (6), pp. 727: 736.

Cherry, K. E.; Park, D. C. and **Donaldson, H.:** 1993, Adult age differences in spatial memory: Effects of structural content and practice, in: *Experimental Aging Research*, 19, pp. 333: 350.

Clarkson, John: 2007, Countering design exclusion – Theory and practice, in: *Design for Inclusivity – A Practical Guide to Accessible, Innovative and User-Centred Design* (Coleman, Roger; Clarkson, John; Dong, Hua and Cassim, Julia, eds.), pp. 165: 180, Gower Publishing Limited.

Colblindor: 2010, *Types of Color Blindness*. Available at: www.color-blindness.com/2010/03/09/types-of-color-blindness/ Accessed February 15, 2015

Colour Blind Awareness: *Causes of Color Blindness*. Available at: www.colourblindawareness.org/colour-blindness/causes-of-colour-blindness/ Accessed February 15, 2015

Colour Blind Awareness: *Types of Color Blindness*. Available at: www.colourblindawareness.org/colour-blindness/types-of-colour-blindness/ Accessed February 15, 2015

Connelly, S.L. and **Hasher, L.:** 1993, Aging and inhibition of spatial location, in: *Journal of Experimental Psychology: Human Perception and Performance*, 19, pp. 1238: 1250.

Coren, S.: 1994, Most comfortable listening level as a function of age, in: *Ergonomics* 37 (7), pp. 1269: 1274.

Cowan, Nelson: 2008, What are the differences between long-term, short-term, and working memory? In: *Progress in Brain Research*, vol. 169, pp. 323: 338. Available at: www.ncbi.nlm.nih.gov/pmc/articles/PMC2657600/

Crooke, T. H. and **Larrabee, G. J.:** 1992, Changes in facial recognition memory across the adult lifespan, in: *Journal of Gerontology: Psychological Sciences*, 47, pp. 138: 141.

Curcio, C.A. and **Drucker, D.N.**: 1993, Retinal ganglion cells in Alzheimer's disease and aging, in: *Annals of Neurology,* 33, pp. 248: 257.

Curcio, C.A.; Millican, C.L.; Allen, K.A. and **Kalina, R.E.:** 1993, Aging of the human photoreceptor mosaic: Evidence for selective vulnerability of rods in central vision, in: *Investigative Ophthalmology and Visual Science,* 34, pp. 3278: 3296.

De Luca, Carlo J.: 1985, Control properties of motor units, in: *Journal of Experimental Biology*, vol. 115, pp. 125: 136. Available at:
http://jeb.biologists.org/content/jexbio/115/1/125.full.pdf

Denny, N. W.; Dew, J. R. and **Kihlstrom, J. F.:** 1992, An adult development study of encoding of spatial location, in: *Experimental Aging Research*, 18, pp. 25: 32.

Desai, M.; Pratt, L.A.; Lentzne, H. and **Robinson, K.N:** 2001, Trends in vision and hearing among older Americans, in: *Aging Trends*, no. 2, CDC: National Center for Health Statistics.

Dixon, R.A.; Kurzman, D. and **Friesen, I.C.:** 1993, Handwriting performance in younger adults: Age, familiarity and practice effects, in: *Psychology and Aging 8*, pp. 360: 370.

Dobbs, Allen R. and **Rule, Brendan G.:** 1987, Prospective memory and self-reports of memory abilities in older adults, in: *Canadian Journal of Psychology*, 41 (2), pp. 209: 222.

Dobbs, Allen R. and **Rule, Brendan G.:** 1989, Adult age differences in working memory, in: *Psychology and Aging*, 4 (4), pp. 500: 503.

Dobie, Robert A. and **Van Hemel, Susan:** 2004, *Hearing Loss: Determining Eligibility for Social Security Benefits*, National Academies Press (US), Washington (DC). Available at:
www.ncbi.nlm.nih.gov/books/NBK207834/ and www.nap.edu/read/11099

Donders, Franciscus Cornelis: 1969, On the speed of mental processes, in: *Acta Psychologica 30 Attention and performance II*, (Koster, W. G.), pp. 412: 431, North-Holland Publishing Company, Amsterdam. Available at:
http://www2.psychology.uiowa.edu/faculty/mordkoff/InfoProc/pdfs/Donders%201868.pdf

eMedicine Dictionary: *Joint*. Available at:
www.emedicinehealth.com/script/main/art.asp?articlekey=4074 Accessed September 7, 2015

Ellis, R. D.; Goldberg, J. H. and **Detweiler, M. C.:** 1996, Predicting age-related differences in visual information processing using a two-stage queuing model, in: *Journal of Gerontology: Psychological Sciences*, 51B, pp. 155: 165.

explorable.com/auditory-system Accessed June 19, 2016

firstyears.org/anatomy/ear.htm Accessed June 19, 2016

Ford, M.: 1993, Coping again: Better sight for elderly people with central vision loss, in: *Broadcasting Support Services*, 91, pp. 6: 28.

Frazier, L. and **Hoyer, W.J.:** 1992, Object recognition by component features, in: *Experimental Aging Research*, 18, pp. 9: 15.

Geldard, F.: 1972, *The Human Senses*, 2nd edition, Wiley, New York.

Gil-Loyzaga, Pablo: *Brain Stem***.** Available at:
www.cochlea.eu/en/auditory-brain/brain-stem Accessed June 19, 2016

Gil-Loyzaga, Pablo: *Thalamo-cortex***.** Available at:
www.cochlea.eu/en/auditory-brain/thalamo-cortex Accessed June 19, 2016

Goldenstein, E. Bruce: 2009, *Sensation and Perception*, 8th edition, Wadsworth, Cengage Learning.

Grady, C. L. and **Craik, F. I. M.:** 2000, Changes in memory processing with age, in: *Current Opinion in Neurobiology*, 10, pp. 224: 231.

Groth, K. E. and **Allen, P. A.:** 2000, Visual attention and aging, in: *Frontiers in Bioscience*, 5, pp. 284: 297.

Hageman, Patricia A.; Leibowitz, Michael and **Blanke, Daniel:** 1995, Age and gender effects on postural control measures, in: *Archives of Physical Medicine and Rehabilitation*, vol. 76, issue 10, pp. 961: 965. Available at: www.archives-pmr.org/article/S0003-9993(95)80075-1/pdf

Hartley, A. A.: 1992, Attention, in: *The Handbook of Aging and Cognition*, (Craik, F. I. M. and Salthouse, T. A., eds.), pp. 3: 49, Lawrence Erlbaum Associates, Hillsdale, NJ.

Hashemi, H.; Khabazkhoob, M.; Jafarzadehpur, E.; Emamian, M. H.; Shariati, M. and **Fotouhi, A.:** 2012, Contrast sensitivity evaluation in a population-based study in Shahroud, Iran, in: *Ophthalmology*, 119 (3), pp. 541: 546.

Hawthorn, D.: 2000, Possible implications of aging for interface designers, in: *Interacting with Computers*, vol. 12, issue 5, pp. 507: 528.

Hearing Loss Association of America: *Basic Facts about Hearing Loss*. Available at:
www.hearingloss.org/content/basic-facts-about-hearing-loss Accessed February 15, 2015

Hearing Loss Association of America: *Types, Causes and Treatment*. Available at:
www.hearingloss.org/content/types-causes-and-treatment Accessed February 15, 2015

Heiting, Gary: *Contrast Sensitivity Testing*. Available at:
www.allaboutvision.com/eye-exam/contrast-sensitivity.htm Accessed February 15, 2015

Helve, J. and **Krause, U.:** 1972, The influence of age on performance in the Panel D15 colour vision test, in: *Acta Ophthalmologica*, 50, pp. 896: 901.

Hess, S.; Detweiler, M. C. and **Ellis, R. D.:** 1999, The utility of display space in keeping-track of rapidly changing information, in: *Human Factors*, 41, pp. 257: 281.

Horn, J. L.: 1970, Organization of data on life span development of human abilities, in: *Lifespan Developmental Psychology: Research and Theory* (Goulet, L. R. and Baltes, P. B., eds.), pp. 423: 466, Academic Press, New York.

Horn, J. L.: 1982, The theory of fluid and crystallized intelligence in relation to concepts of cognitive psychology and aging in adulthood, in: *Aging and Cognitive Processes*, 8, (Craik, F.I.M. and Trehub, S., eds.), pp. 237: 278, Plenum Press, New York.

Horn, J. L. and **Donaldson, G.:** 1976, On the myth of intellectual decline in adulthood, in: *American Psychologist*, 31, pp. 701: 709.

Howard, James H. and **Howard, Darlene V.:** 1997, Learning and memory, in: *Handbook of Human Factors and the Older Adult*, (Fisk, Arthur D. and Rogers, Wendy A., eds.), pp. 7: 26, Academic Press, San Diego, CA, US.

Hoyer, W.J. and **Rybash, J.M.:** 1992, Age and visual field differences in computing visual-spatial relations, in: *Psychology and Aging*, 7, pp. 339: 342.

Huey, R. W.; Buckley, D. S. and **Lerner, N. D.:** 1994, Audible performance of smoke alarm sounds, in: *The Proceedings of the Human Factors and Ergonomics Society*, 38th annual meeting, October 24: 28, Nashville, Tennessee, pp. 147: 151, Santa Monica, CA: HFES.

InnerBody: *Muscular System*. Available at:
www.innerbody.com/image/musfov.html Accessed September 7, 2015

InnerBody: *Skeletal System*. Available at:
www.innerbody.com/image/skelfov.html Accessed September 7, 2015

Jensen, Arthur R.: 2006, *Clocking the Mind: Mental Chronometry and Individual Differences*, 1st edition, Elsevier. Available at:
http://emilkirkegaard.dk/en/wp-content/uploads/Arthur_R._Jensen_Clocking_the_Mind_Mental_ChronBookos.org_.pdf

jjkvc.org/#!visual-system/c1hdj Accessed June 19, 2016

Kausler, Donald H.: 1994, *Learning and Memory in Normal Aging*, Academic Press, San Diego.

Ketcham, Caroline J. and **Stelmach, George E.:** 2004, Movement control in the older adult, in: *Technology for Adaptive Aging*, (Pew, Richard W. and Van Hemel, Susan B., eds.), pp. 64: 92, National Research Council of National Academies, Washington (DC). Available at:
www.ncbi.nlm.nih.gov/books/NBK97342/

Kinzel, Erin and **Jacko, Julie A.:** 2009, Sensory impairments, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 6-1: 6-14, CRC Press, Taylor & Francis Group, Boca Raton/London/New York.

Kline, Donald W. and **Scialfa, Charles T.:** 1997, Sensory and perceptual functioning: Basic research and human factors implications, in: *Handbook of Human Factors and the Older Adult* (Fisk, Arthur D. and Rogers, Wendy A., eds.), pp. 27: 54, Academic Press, San Diego, CA, US.

Kotary, L. and **Hoyer, W: J.:** 1995, Age and the ability to inhibit distractor information in visual selective attention, in: *Experimental Aging Research*, 21, pp. 159: 171.

Kurniawan, Sri: 2009, Age-related differences in the interface design process, in: *The Universal Access Handbook*, (Stephanidis, Constantine, ed.), pp. 8-1: 8-12, CRC Press, Taylor & Francis Group, Boca Raton/ London/ New York.

Levenson, Jeffrey H. and **Kozarsky, Alan:** 1990, Visual acuity, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 115, Emory University School of Medicine, Atlanta, Georgia.

Levenson, Jeffrey H. and **Kozarsky, Alan:** 1990, Visual acuity change, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 111, Emory University School of Medicine, Atlanta, Georgia.

Light, L. L.: 1990, Memory and language in old age, in: *Handbook of the Psychology of Aging*, 3rd edition, (Birren, James E. and Schaie, K. Warner, eds.), pp. 275: 290, Academic Press, San Diego, CA, US.

Lipman, P. D. and **Caplan, L. J.:** 1992, Adult age differences in memory for routes: Effects of instruction and spatial diagram, in: *Psychology and Aging*, 7, pp. 435: 442.

Lupinacci, N. S.; Rikli, R. E. and **Jones, C. J.:** 1993, Age and physical activity effects on reaction time and digit symbol substitution performance in cognitively active adults, in: *Research Quarterly for Exercise and Sport* 64, pp. 144: 150.

Masland, Richard H.: 2001, The fundamental plan of the retina, in: *Nature Neuroscience*, vol. 4, no. 9, pp. 877: 886.

McDowd, J. M. and **Craik, F. I. M.:** 1988, Effects of aging and task difficulty on divided attention performance, in: *Journal of Experimental Psychology: Human Perception and Performance*, 14, pp. 267: 280.

Medical dictionary: *Motor unit*. Available at:
http://medical-dictionary.thefreedictionary.com/ Accessed September 7, 2015

MedlinePlus: *Aging changes in the bones – muscles – joints*. Available at:
https://medlineplus.gov/ency/article/004015.htm Accessed June 19, 2016

MedlinePlus: *Ear anatomy*. Available at:
https://medlineplus.gov/ency/imagepages/1092.htm Accessed June 19, 2016

MedTerms medical dictionary: *Proprioception*. Available at:
www.medicinenet.com/script/main/art.asp?articlekey=6393 Accessed September 7, 2015

Miller, G. A.: 1956, The magical number seven, plus or minus two: Some limits on our capacity for processing information, in: *Psychological Review*, vol. 101, no. 2, pp. 343: 352.

Miller, G. A.; Galanter, E. and **Pribram, K.H.:** 1960, *Plans and the Structure of Behavior*, Holt, Rinehart and Winston, New York.

Miller, J.; Slomczynski, K. M. and **Kohn, M. L.:** 1987, Continuity of learning-generalization through the life span: The effect of job on men's intellectual process in the United States and Poland, in: *Cognitive Functioning and Social Structure over the Life Course*, (Schooler, C. and Schaie, K. Warner, eds.), pp. 176: 202, Ablex, Norwood, NJ.

Motorneuron mapping. Available at:
www.eng.mu.edu/wintersj/muscmod/nms-func-physiology/nm-map.htm Accessed September 7, 2015

National academy on an aging society: 1999, *Hearing Loss – A Growing Problem that Affects Quality of Life*, no. 2, December. Available at:
www.agingsociety.org/agingsociety/pdf/hearing.pdf

NEI: *Facts about Color Blindness*. Available at:
https://nei.nih.gov/health/color_blindness/facts_about Accessed February 15, 2015

NHS choices: *Colour Vision Deficiency – Causes*. Available at:
www.nhs.uk/Conditions/Colour-vision-deficiency/Pages/Causes.aspx Accessed February 15, 2015

NIDCD: 2014, *Age-Related Hearing Loss*. Available at:
www.nidcd.nih.gov/health/hearing/Pages/Age-Related-Hearing-Loss.aspx Accessed February 15, 2015

NIDCD: 2014, *Quick Statistics*. Available at:
www.nidcd.nih.gov/health/statistics/pages/quick.aspx Accessed February 15, 2015

Ounjian, M.; Roy, R. R.; Eldred, E.; Garfinkel, A.; Payne, J. R.; Armstrong, A.; Toga, A. and **Edgerton, V.R.:** 1991, Physiological and developmental implications of motor unit anatomy, in: *Journal of Neurobiology*, vol. 22, Issue 5, pp. 547: 559.

Owsley, C.; Sekuler, R. and **Siemsen, D.:** 1983, Contrast sensitivity throughout adulthood, in: *Vision Research*, 23, pp. 689: 699.

Oyster, Clyde W.: 1999, *The Human Eye: Structure and Function*, Sinauer Associates, Inc.

Plude, D.J. and **Hoyer, W.J.:** 1981, Adult age differences in visual search as a function of stimulus mapping and processing load, in: *The Journal of Gerontology*, 36, pp. 598: 604.

Pujol, Remy: *Auditory Brain.* Available at:
www.cochlea.eu/en/auditory-brain Accessed June 19, 2016

Quadagno, Jill S.: 2017, *Aging and the Life Course: An Introduction to Social Gerontology*, 7th edition, kindle edition, McGraw-Hill Education.

Ranganath, Charan C.; Cohen, Michael X. and **Brozinsky, Craig J.:** 2005, Working memory maintenance contributes to long-term memory formation: Neural and behavioral evidence, in: *Journal of Cognitive Neuroscience*, vol. 17, no. 7, pp. 994: 1010.

Ratner, H. H; Schell, D. A.; Crimmins, A.; Mittleman, D. and **Baldinelli, L.:** 1987, Changes in adults prose recall: Aging or cognitive demands, in: *Developmental Psychology*, 23, pp. 521: 525.

Rogers, W.A. and **Fisk, A.D.:** 1991: Age-related differences in the maintenance and modification of automatic processes: Arithmetic stroop interference, in: *Human Factors*, *The Journal of the Human Factors and Ergonomics Society,* 33, pp. 45: 56.

Rogers, W.A.; Fisk, A.D. and **Hertzog, C.:** 1994, Do ability-performance relationships differentiate age and practice effects in visual search? In: *Journal of Experimental Psychology, Learning, Memory and Cognition*, 20, pp. 710: 738.

Royal National Institute for the Blind: 2014, *Key Information and Statistics*. Available at: www.rnib.org.uk/knowledge-and-research-hub/key-information-and-statistics Accessed February 15, 2015

Said, F.S. and **Weale, R.A.:** 1959, The variations with age of the spectral transmissivity of the living human crystalline lens, in: *Gerontologia,* 3*,* pp. 213: 231.

Salthouse, Timothy A.: 1994, The aging of working memory, in: *Neuropsychology*, 8, pp. 535: 543.

Salthouse, Timothy A.: 2009, When does age-related cognitive decline begin? In: *Neurobiology of Aging*, vol. 30 (4), pp. 507: 514.

Salthouse, T.A. and **Prill, K.A.:** 1988, Effects of aging on perceptual closure, in: *American Journal of Psychology*, 101, pp. 217: 238.

Schacter, Daniel L.; Gilbert, Daniel T. and **Wegner, Daniel M.:** 2011, *Psychology*, 2nd edition, Worth Publishers, New York.

Schaie, K. W.: 1989, The hazards of cognitive aging, in: *Gerontologist*, 29, pp. 484: 493.

Schaie, K. W.: 1996, Intellectual development in adulthood, in: *Handbook of the Psychology of Aging*, 4th edition, (Birren, James E. and Schaie, K. Warner, eds.), pp. 266: 286, Academic Press, San Diego, CA, US. Available at: https://sharepoint.washington.edu/uwsom/sls/Documents/1990/Intell-Dev-in-Adulthood.pdf

Schieber, Frank: 1992, Aging and the senses, in: *Handbook of Mental Health and Aging*, (Birren, J. E., Sloane, R. B. and Cohen, G. D., eds.), pp. 251: 306, Academic Press, New York.

Schieber, Frank: 2003, Human factors and aging: Identifying and compensating for age-related deficits in sensory and cognitive function, in: *Impact of Technology on Successful Aging*, (Charness, Nail and Schaie, K.Warner, eds.), pp. 42: 84, Springer Publishing Company, Inc., New York.

Schulte, Osa Jackson; Stephens, James and **Ann, Joyce:** 2013, Aging, dementia, and disorders of cognition, in: *Neurological Rehabilitation*, (Umphred, Darcy A.; Lazaro, Rolando T.; Roller, Margaret L. and Burton, Gordon U., eds.), 6th edition, pp. 835: 862, Elsevier, USA.

Schwerin, Susan: 2013, *The Anatomy of Movement*. Available at: http://brainconnection.brainhq.com/2013/03/05/the-anatomy-of-movement/ Accessed September 7, 2015

Sharit, J. and **Czaja, S.:** 1994, Ageing, computer-based task performance and stress: Issues and challenges, in: *Ergonomics*, 37, pp. 559: 577.

Sia, D. I.; Martin, S.; Wittert, G. and **Casson R.J.:** 2013, Age-related change in contrast sensitivity among Australian male adults: Florey adult male ageing study, in: *Acta Ophthalmology*, 91(4), pp. 312: 317.

Siedler, R. and **Stelmach, G.:** 1996, Motor control, in: *Encyclopedia of Gerontology*, (Birren, J.E., ed.), pp. 177: 185, Academic Press, San Diego, CA.

Sliwinski, M. J. and **Hall, C. B.:** 1998, Constraints on general slowing: A meta-analysis using hierarchical linear models with random coefficients, in: *Psychology and Aging*, 13, pp. 164: 175.

Smith, Anderson D.: 1996, Memory, in: *Handbook of the Psychology of Aging*, 4th edition, (Birren, James E. and Schaie, K. Warner, eds.), Academic Press, San Diego, CA, US.

Smith, M. W.; Sharit, J. and **Czaja, S. J.:** 1999, Aging, motor control and the performance of computer mouse tasks, in: *Human Factors* 41, 389: 396.

Spector, A.: 1982, Aging of the lens and cataract formation, in: *Aging and Human Visual Functions* (Sekuler, R., Kline, D. and Dismukes, K., eds.), pp. 27: 43, New York: Alan R. Liss.

Spector, Robert H.: 1990, Visual fields, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 116, Emory University School of Medicine, Atlanta, Georgia. Available at:
www.ncbi.nlm.nih.gov/books/NBK220/

Spiriduso, W.W.: 1995, Aging and motor control, in: *Perspectives in Exercise Science and Sports Medicine: Exercise in Older Adults*, (Lamb, D.R., Gisolfi, C.V. and Nadel, E., eds.), pp. 53: 114, Cooper, Carmel, IN.

St. Luke's Cataract & Laser Institute: *Cataract*. Available at:
www.stlukeseye.com/conditions/cataracts.html Accessed February 15, 2015

St. Luke's Cataract & Laser Institute: *Presbyopia*. Available at:
www.stlukeseye.com/Conditions/presbyopia.html Accessed February 15, 2015

Sypert, George W. and **Munson, John B.:** 1981, Basis of segmental motor control: Motoneuron size or motor unit type? In: *Neurosurgery*, vol. 8, issue 5, pp. 608: 621.

Tewfik, Ted L. and **Gest, Thomas R.:** *Auditory System Anatomy*. Available at:
http://emedicine.medscape.com/article/1948643-overview#showall Accessed October 11, 2016

Tromp, A. M.; Pluijm, S. M. F.; Smit, J. H.; Deeg, D.J.; Bouter, L.M. and **Lips, P.:** 2001: Fall-risk screening test: A prospective study on predictors for falls in community-dwelling elderly, in: *Journal of Clinical Epidemiology*, 54(8), pp. 837: 844.

Turner, John S., JR.: 1990, The ear and auditory system, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 126, Emory University School of Medicine, Atlanta, Georgia. Available at:
www.ncbi.nlm.nih.gov/books/NBK231/

Turner, John S., JR. and **Per-Lee, John H.:** 1990, Auditory dysfunction: Hearing loss, in: *Clinical Methods: The History, Physical, and Laboratory Examinations*, (Walker, H. Kenneth; Hall, W. Dallas and Hurst, J. Willis, eds.), 3rd edition, chapter 120, Emory University School of Medicine, Atlanta, Georgia. Available at: www.ncbi.nlm.nih.gov/books/NBK225/

Vera-Díaz, Fuensanta A. and **Doble, Nathan:** 2012, The human eye and adaptive optics, in: *Topics in Adaptive Optics*, (Tyson, Bob, ed.), pp. 119: 150, InTech. Available at: www.intechopen.com/books/topics-in-adaptive-optics/the-need-for-adaptive-optics-in-the-human-eye

Vercruyssen, Max: 1997, Movement control and the speed of behavior, in: *Handbook of Human Factors and the Older Adult*, (Fisk, Arthur D. and Rogers, Wendy A., eds.), pp. 55: 86, Academic Press, San Diego, CA, US.

Waller, Sam and **Clarkson, John:** Framework section, in: *Inclusive Design Toolkit*. Available at: www.inclusivedesigntoolkit.com/betterdesign2/UCframework/framework.html Accessed February 15, 2015

Weale, R.A.: 1961, Retinal illumination and age, in: *Transactions of the Illuminating Engineering Society,* 26, pp. 95: 100.

WHO: 2001, *International Classification of Functioning, Disability and Health (ICF)*, Geneva.

WHO: 2015, *Dementia*, fact sheet no. 362, March. Available at: www.who.int/mediacentre/factsheets/fs362/en/

WHO: *Chronic Rheumatic Conditions*. Available at: www.who.int/chp/topics/rheumatic/en/# Accessed February 15, 2015

Wikipedia: *Alzheimer's Disease*. Accessed February 15, 2015

Wikipedia: *Ametropia* or *Refractive Error*. Accessed February 15, 2015

Wikipedia: *Cognition*. Accessed February 15, 2015

Wikipedia: *Cognition Science*. Accessed February 15, 2015

Wikipedia: *Color Blindness*. Accessed February 15, 2015

Wikipedia: *Cone Cell*. Accessed February 15, 2015

Wikipedia: *Contrast (Vision)*. Accessed February 15, 2015

Wikipedia: *Decibel*. Accessed February 15, 2015

Wikipedia: *Human Musculoskeletal System*. Accessed September 7, 2015

Wikipedia: *Long-term Memory*. Accessed February 15, 2015

Wikipedia: *Mental Chronometry*. Accessed February 15, 2015

Wikipedia: *Mind*. Accessed February 15, 2015

Wikipedia: *Motor Control*. Accessed September 7, 2015

Wikipedia: *Motor Unit*. Accessed September 7, 2015

Wikipedia: *Motor Unit Recruitment*. Accessed September 7, 2015

Wikipedia: *Muscle*. Accessed September 7, 2015

Wikipedia: *Perception*. Accessed February 15, 2015

Wikipedia: *Peripheral Vision*. Accessed February 15, 2015

Wikipedia: *Proprioception*. Accessed September 7, 2015

Wikipedia: *Sense*. Accessed September 7, 2015

Wikipedia: *Short-term Memory*. Accessed February 15, 2015

Wikipedia: *Tetanic Contraction*. Accessed September 7, 2015

Wikipedia: *Working Memory*. Accessed February 15, 2015

Wingfield, A.; Stine, A.L.; Lahar, C.J. and **Aberdeen, J.S.:** 1988, Does the capacity of working memory change with age? In: *Experimental Aging Research*, 14, pp. 103: 107.

Youdelis, C. and **Hendrickson, A.:** 1986, A qualitative and quantitative analysis of the human fovea during development, in: *Vision Research,* 26*,* pp. 847: 855.

Zajicek, M.: 2001, Special interface requirements for older adults, in: *The Proceedings of the WUAUC'01, 2001 EC/NSF workshop on Universal Accessibility of Ubiquitous Computing: Providing for the Elderly*, May 22: 25, Alcácer do Sal, Portugal, pp. 60: 65, ACM Press, New York, USA.

Zarbin, M. A.: 1998, Age-related macular degeneration: Review of pathogenesis, in: *European Journal of Ophthalmology*, 8, pp. 199: 206.