Design for Inclusion, Gamification and Learning Experience

edited by
Francesca Tosi, Antonella Serra, Alessia Brischetto, Ester Iacono

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Ergonomia&**Design**

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La serie propone studi, ricerche e sperimentazioni progettuali, condotti nel campo dell'Ergonomia e Design / Ergonomics in Design, nei diversi campi nei quali gli strumenti metodologici dell'Ergonomia e dello Human-Centred Design, uniti alla dimensione creativa e propositiva del Design, rappresentano importanti fattori strategici per l'innovazione di prodotti, ambienti e servizi e per la competitività del sistema produttivo.
Moltissimi sono i settori di ricerca e i campi di sperimentazione nei quali il Design si confronta e si integra sia con le componenti più consolidate dell'Ergonomia (fisica, cognitiva, dell'organizzazione) che con i più recenti contributi dello Human-Centered Design e della User Experience.
Obiettivo della serie è fornire il quadro del vasto panorama scientifico in questo settore, che spazia dall'ambiente domestico agli strumenti per l'attività sportiva, dalla cura della persona agli ambienti e i prodotti per la sanità e per l'assistenza, dai prodotti e servizi per la mobilità urbana ii molti altri ambiti, nei quali il rapporto tra Ergonomia e Design rappresenta un concreto fattore di innovazione.

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ITU – Istanbul Technical University, Department of Interior Architecture, Istanbul, Turkey

Partner HEIs *(listed in alphabetical order)*

BAU – Bahçeşehir University, Game Lab, Istanbul, Turkey

LAB – Institute of Design and Fine Arts, Lahti, Finland

POLIMI – Department of Design, Milano, Italy

TH OWL - OWL University of Applied Sciences and Arts, Department Detmold School of Architecture and Interior Architecture, Germany

UNIFI – Department of Architecture, University of Florence, Florence, Italy

Partner NGOs

SERCEV – The Association for Well-being of Children with Cerebral Palsy, Ankara, Turkey

OccuTherapy – The Occupational Therapy Association of Turkey, Ankara, Turkey

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PUDCAD – Practicing Universal Design Principles in Design Education through a CAD-Based Game

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Preface

by Ozge Cordan and Demet Arslan Dincay

"The Practicing Universal Design Principles in Design Education through a CAD-Based Game", PUDCAD, is an EU PROJECT, coordinated by ISTANBUL TECHNICAL UNIVERSITY, founded by Erasmus+ Program KA203 and conducted by the Center for European Union Education and Youth Programs.

All of PUDCAD partners, ITU, Department of Interior Architecture, Istanbul, Turkey; TH-OWL, OWL University of Applied Sciences and Arts, Department Detmold School of Architecture and Interior Architecture, Detmold, Germany; LAB, Institute of Design and Fine Arts, Lahti, Finland; UNIFI, University of Florence, Florence, Italy; POLIMI, Department of Design, Milano, Italy; BAU, Faculty of Communication, Istanbul, Turkey; SERCEV, The Association for Well-being of Children with Cerbral Palsy, Turkey; ED, The Occupational Therapy Association of Turkey, contribute and improve the project with their broad experiences and proficiencies on Universal Design, education and research hand in hand.

PUDCAD Project aims to support and strengthen the Universal Design awareness in education within international networks. It not only tries to integrate Universal Design principles to design education, but also widens the awareness of students about accessible design as an important topic for national policies and researchers. The main output of the PUDCAD Project involves a design game on a CAD-Based platform which aims that undergraduate design students would learn and practice the Universal Design principles through an empathetic approach. The game will focus especially on inclusive high school design for the students with Cerebral Palsy (CP) that includes several distinct forms of impairment of motor functions which cause different movement disorders.

PUDCAD Project is a three year project (01.09.2017-01.09.2020) and it includes 5 student workshops, 4 teaching at student workshops as learning, teaching, training activities and 3 conferences as multiplier events during this term. Conferences will actively help to reach more people and disseminate the aims and outputs of the project.

As part of PUDCAD Project, the conference (E3) was organized by Department of Architecture (DIDA), one of the project's partner on the 10th of May, 2019 at Florence, Italy. The one-day conference was themed as "Designing for Inclusive Learning Experience". The conference has three sections titled as "Design for Inclusion", "Game and Gamification Experience" and "Design for Learning" sequentially. After Ozge Cordan's speech on "PUDCAD Project" and Francesca Tosi's speech on "Ergonomics and Design", there were oral, digital and poster presentations as well as student's presentations of PUDCAD Florence Workshop in the conference.

In this scope, the proceedings book has 37 papers including contributions of Ester Iacono, Alessia Brischetto and Antonella Serra as chairs of each session in the conference. The following papers explores the related subjects in detail. Within this general framework, we believe that the proceeding book will widen the perception and perspectives of both PUDCAD Project's partners and the other audiences participated to the conference.

Introduction

by Francesca Tosi

The book presents contributions on Ergonomics and Design/Human-Centred Design submitted at the Conference "Designing for Inclusive Learning Experience" (10 May 2019, Florence – Italy) which offered researchers and professionals a forum to share research and best practices in this scientific field. The conference topics regard the application of Human Factors to training, education, learning sciences, and Universal Design for learning.

The Ergonomics approach, and Human-Centred Design/User Experience principles and methods, applied in recent years in the fields of interface design and product design, are also beginning to develop today in the field of training, education and learning experiences. In particular, the principles of behavioral and cognitive science, combined with design, are extremely relevant to educational content design and the effective application of technology to provide an appropriate learning experience.

The frame in which the conference is located is a program of three multipliers events. The first one – entitled "Man, space and inclusion" (19 October 2018, Detmold, Germany) – had the purpose of investigation the UNIVERSAL DESIGN and the last one (24-26 June 2020, Istanbul, Turkey) will focus on the macro-theme PLAY AND EDUCATION.

The area of interest of this second conference is, therefore, the Ergonomics and Design/Human-Centred Design approach in all project-facing joints – physical and virtual – for learning and in particular: Ergonomics in Design, Universal Design and Learning Experience (theory and good practices), Human-Centred Design and User Experience, Game Design and Gamification, Competency-based learning, Designing the learning experience, Learner engagement e-learning, Mobile learning), Web-based training, Blended learning, Usability of learning technology, Advanced learning technologies.

The authors participated in three forms: oral presentation, poster presentation and digital presentation. In particular, the latter mode of participation has been encouraged to facilitate the participation of territorially distant scholars: New Zealand, India, USA, South America etc. and allowed the comparison to be extended to a very large number of researchers, creating an opportunity of considerable interest for dialogue on these issues. The 36 submissions presented to the Conference were written by 101 authors from 9 countries – Italy, America, Brazil, New Zealand, India, Japan, Turkey, Germany, Finland – and were divided into three main areas – Design for inclusion, Game and Gamification Experience, Design for Learning, which correspond to the three parts of the volume. The research results and the design application presented are of great interest and they describe the state of the art in the three areas covered.

I PART

DESIGN FOR INCLUSION

1. Ergonomics and Design. Inclusive Design

by Francesca Tosi

1.1 Introduction

To paraphrase a well known definition by Rubin[1], *Ergonomics in Design* can be classified as a philosophy of intervention which, starting from principles and contents of the Human-Centred Design, identifies in the humans/users, and in the totality of their needs, the starting point and central objective of the design action and, at the same time, a methodological approach capable of identifying and evaluating the complexity and specificity of these needs and transforming them into design intervention capacities.

In order to do this, *Ergonomics in Design* is based on cognitive instruments and on the evaluation procedures elaborated in the "Human Factor" field, that is, the so-called traditional Ergonomics, and also on the methodological principles and methods belonging to Human-Centred Design and, more specifically, on a concept of the design approach that places the humans/users and their needs in the centre of every evaluation and design intervention.

The area of ergonomic research and practice in *Ergonomics in Design* has in fact developed over recent years along a dual pathway – theoretical and methodological – which has led to an expansion of the interest in Ergonomics from the evaluation of the characteristics and the skills of humans, to the evaluation and interpretation of the needs and expectations of the individual-user in his/her relationship with the products, and to the defining in a conclusive manner of his/her design role.

Starting from the principles and methodological approach of the Human-Centred Design, created as part of the cognitive Ergonomics in the field of studies on the Human Computer Interaction, from the nineties onwards the focus of Ergonomics was directed towards the centrality of the person and his/her needs in all fields of the ergonomic intervention. In parallel, the contents of the Ergonomics were gradually shifting from the objective evaluation of products and systems, to the design of new intervention solutions.

Ergonomics/Human-Centred Design and Design for inclusion therefore move with similar objectives and today tend to identify themselves on the basis of the common attention with which they deal with the specificity and complexity of each case of intervention (be it of evaluation or design of a product as well as an environment or service) from the identification of the specificity of needs that people express – or can express – with respect to interaction with products, environments and services, and more in systems with which they relate.

In theoretical terms, the Design for All approach has been gradually shifting from an approach entailing pronounced specialisation aimed at meeting the needs and expectations of people with disabilities, to a fully conclusive approach which, starting from the needs of specific user sectors, has concentrated on creating products capable of meeting the needs and expectations of the totality of users.

As Elton and Nicolle write (2015, pp. 300-301), *"the inclusive design approach, aims to deliver "mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design" (BS 7000-6 2005). Accessibility and usability are the key criteria of this approach. Accessibility refers to allowing users access to the features of products and/or services through their sensory, physical and cognitive capabilities"*[2].

A similar path has also been followed in the field of Ergonomics/Human-Centred Design, in which, over the years the original nucleus of knowledge about human characteristics and abilities, and the study of the safety conditions of workplaces and occupational activities have been flanked by knowledge, evaluation methods, and operational practices coming from increasingly more widespread disciplinary areas and intervention sectors: from cognitive psychology to computer engineering, from anthropology to sociology, to design of the product and communication, for the purpose of studying the totality of aspects that define the interaction between individuals and the systems in which they operate during their work activities and everyday life.

The IEA, International Ergonomics Association defines Ergonomics *"the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well-being and overall system performance. Practitioners of ergonomics, ergonomists, contribute to the planning, design and evaluation of tasks, jobs, products, organizations, environments and systems in order to make them compatible with the needs, abilities and limitations of people".*

The study, evaluation and design of the interaction, therefore, are in the spotlight, meaning the plurality of relationships (physical, sensorial and cognitive) that humans establish – or able to establish – with the products, environments and technological and social systems, and in which they carry out their work activities and everyday life. These relationships are assessed in their specificity and determined by the different and possible contexts and their variability over time.

The jumping-off point for any evaluation and/or planning intervention for Ergonomics in Design is identifying and interpreting the needs of the people who actually enter – or can enter – into a relationship with the product or system, within a specific usage context, and the translation of these needs into the design requirements.

In other words, the traditional evaluation of the "skill levels" or "inability" of users (which were rigid by necessity and often insufficient to define the different and multiple realities of the human condition) is replaced by a design approach that is centered on the reality of needs and expectations shared by different people (in terms of age, level of autonomy and health conditions), and can relate to each individual at different stages of his life.

In operational terms, it is a matter of passing from a design "for disabled people", "for elderly", "for the blind" etc., to a design aimed at ensuring and/or enhancing the usability and handling of products, the simplicity and comprehensibility of their usage methods, and the visibility and legibility of the components, written indications, symbols and icons used to understand them, etc.

The central aspect is to assume the needs, expectations and desires of people with reduced capacity (motor, perceptive, cognitive) are a normal component of the collection of needs that the design must satisfy; we can recognise, in these needs – permanently or temporary – people who are diverse in terms of age, health conditions, economic possibilities, cultural level.

To make daily use products that are completely usable, safe and pleasant to use, therefore, means not adapting products that were originally designed for optimal capacity and "average" needs and making them accessible to people with reduced capacity (of movement, perception, etc.) but – conversely – restructuring the design process, starting from the highest level of needs and expectations, and from the lower level of ability, to create products that are pleasant and easy to use for everyone.

1.2 The Knowledge of the Context of Use as the Basis of the Design

As we have already seen, the Ergonomics in Design approach to the evaluation of the needs of the user foresees the evaluation and interpretation of the complex of variables that define the "context of the interaction", that is the series of factors that from time to time define the conditions in which the individual enters into a relationship with a product, an environment or a service. First and foremost amongst these, the users' characteristics and abilities and the activities they are called on to perform, their goals and expectations, as well as the characteristics of the physical, social, technological environment.

The goal of a fully Inclusive Design is to assume the needs, expectations and desires of people with a reduced capacity (motor, perceptive, cognitive) as a regular component of the collection of needs to which the design has to respond. In these needs, we can recognise – permanently or temporarily – people of different ages, health conditions, economic possibilities and cultural level.

Reduced capacity or ability are related to the conditions of disability and, as we have seen in the previous sections, the entire range of conditions of *distance* from what is commonly viewed as a normal skill.

The concrete effects of this distance – that is, the consequences on daily life and relationships – depend largely on the contextual conditions in which the person lives.

The social changes of recent years, and the growing attention to the needs – and rights – of the population segments at risk of exclusion, have gone hand in hand with an equally growing attention by companies towards the "new" old people market.

The first consideration relates to the shift over time of the age of *old age,* and the consolidation of a segment of the population that carries specific safety and usability needs, with respect to the use of environments, products and services, and are increasingly aware of their rights and needs.

The age of the so-called *old age* now corresponds to much more advanced age than in the recent past. If the demographics put the date of entry into the third age at 60 or 65 years, the 60-year-olds are also defined in journalistic and commercial terms as young elderly, while the age groups immediately higher as active retired, elderly in good health conditions etc..

The second consideration relates, in fact, is the spread of a greater awareness of one's own needs and rights, including with regard to the preservation of one's personal autonomy. Compared to the younger population, the older per-

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son also has a more thoughtful attitude towards the choice of new products, and a greater focus on quality as reliability and safety and also as easy-to-use, familiarity, and so on.

Companies are now turning to the new market of eldery people, and for safe and easy-to-use products (so-called "user friendly" products), proposing solutions potentially aimed at very wide groups of possible buyers, i.e. to all those who, for the most different reasons, are attentive to safety, well-being and ease of use. It can be said that the exponential growth of the new *eldery people market* has overcome the traditional subdivision between "everage" products and "for disabled" products, which, though there are many exceptions, has sadly characterised production until a few years ago.

1.3 Design for Inclusion: Intervention Examples

Concrete examples of a fully inclusive approach to design are any solutions aimed at crafting products based on the specific needs of people with reduced capabilities, which can be easily used by any user: designing traditional telephones with keys that are sized to be easily identified by sight and touch and that can be easily used without pressing two or more at the same time; the use of writing that can be read by shortsighted or presbyopic people; attention to the correct ratio of colour and contrast between the figure (for example, symbols and warnings written on the outside of household appliances, televisions, telephones, etc.) and the background they are placed on; the use of shapes that are easy to handle and manipulate for handles and systems used

Figs. 1.1, 1.2 - Touch screens devices. Examples

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Figs. 1.3, 1.4 - Bathroom suitable for people of reduced mobility © Studio Quadrato

for opening and the provision of doors and walkways that are accessible for people with wheelchairs or walking aids too, etc. These solutions represent design focuses that can respond not only to the needs of specific categories of users, but also simply make it easier, safer and more enjoyable for anyone to use everyday products.

Many interesting examples are in the field of bathroom furniture systems, with different configurations, equipped with accessories that can be inserted according to your needs, thus allowing different modulations of the system from the basic configuration without any movement aids, the full configuration with all the elements necessary for the movement of a wheel chair (Figs. 1.5, 1.6, 1.7). Similar examples are kitchen furniture systems that provide different configurations of base containers and high wall containers according to different needs, from the most accessible solutions (with the space under the worktop completely can also be used with the wheel chair or at any rate from the seated position) to the solutions of maximum use of the available space, with the entire wall surface fully exploited (Fig. 1.7).

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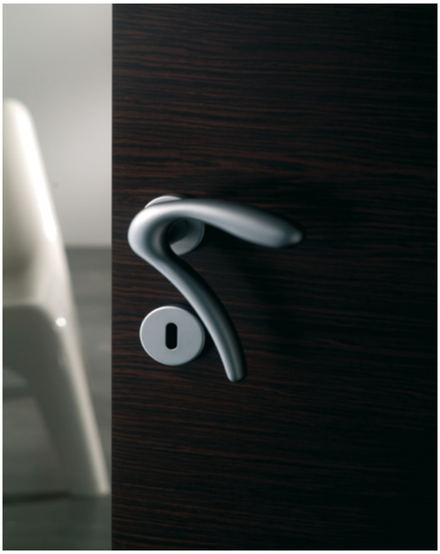

Figs. 1.5, 1.6 - Leonardo Handle © Ghidini

Fig. 1.7 - Sky cuisine © Snaidero

Notes

[1] Reference is made to the definition Rubin (1994) according to whom "*User-Centred Design not only represents the techniques, processes, methods and procedures necessary for verifying and designing the usability of the products and systems, but also and above all, an intervention philosophy that places the user in the centre of the design and creation process of the products*".

[2] In recent years, we have seen social policies promoted by the Europe Union, and European funding for research, in the field of inclusion and social innovation.
The "Europe 2020 leading strategy" sets the goal for a smart, sustainable and inclusive economy, based on developing social inclusion and innovation, defining the latter in this way: "*Social innovation can be defined as the development and implementation of new ideas (products, services and models) to meet social needs and create new social relationships or collaborations. It represents new responses to pressing social demands, which affect the process of social interactions. It is aimed at improving human well-being. Social innovations are innovations that are social in both their ends and their means. They are innovations that are not only good for society but also enhance individuals' capacity to act*". The chief elements of social innovation are:

- identification of new/unmet/inadequately met social needs;
- development of new solutions in response to these social needs;
- evaluation of the effectiveness of new solutions in meeting social needs;
- scaling up of effective social innovations.

(European Commission, Guide to Social Innovation, European Union, 2013).

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2. Design for Inclusion. Good Design is Inclusive and Improves the Future

by Ester Iacono

Numerous case studies demonstrate how Inclusive Design can foster innovation and better design. The contributions collected in this section, entitled "Design for Inclusion", give voice to professionals and researchers who took part in the "Design for inclusive Learning Experience" conference[1], held in Florence on May 10, 2019. Contributions that allow us to open reflections on issues of inclusiveness, care for individuals' needs, social responsibility of design in all disciplines.

Nowadays, we talk a lot about inclusiveness and above all social inclusion, as a concept that embraces many aspects and contexts of our everyday life. The need to reach a collective awareness of inclusive practices, starting from exclusionary factors, becomes increasingly urgent. Fig. 2.1, in a very illustrative way, allows us to understand "inclusion" starting from entirely different concepts such as exclusion, segregation, and integration:

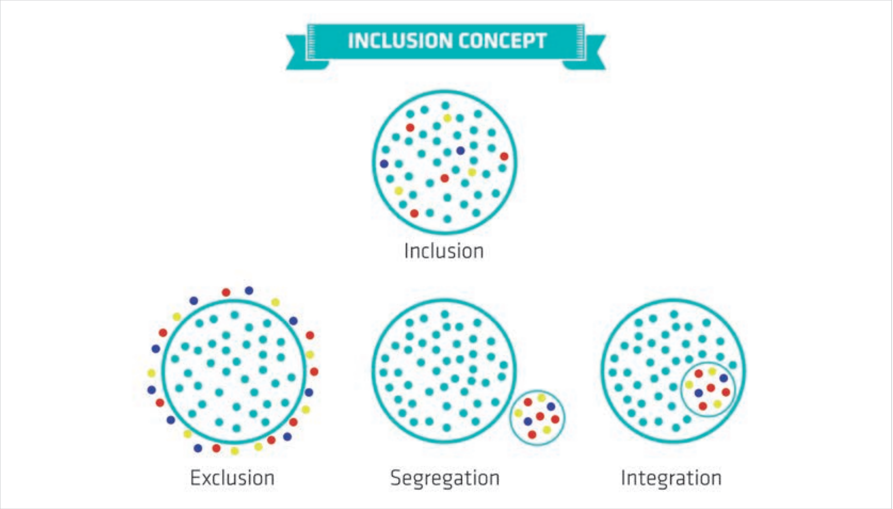

Fig. 2.1 - Graphical representation of the concept of inclusion[2]

- exclusion involves leaving or putting the different out of context;
- segregation involves isolating a person by force or voluntarily from contact with others;
- integration completes what was not and by integrating a "diversity" within it, it creates an asymmetrical relationship, shifting attention to the individual to find specialist answers;
- inclusion, on the other hand, guarantees the inclusion of each individual regardless of limiting factors or elements and activates asymmetrical relationships between peers.

In particular, since inclusion is the basis of daily news on government policies and the representation of excluded groups, in traditional industries, there is a growing interest in making inclusion a common goal for companies, design/ research teams and products /services.

For this reason, we can speak of Inclusive Design, a well-established, but still young, discipline defined by the British Standards Institute (2005) as: *"The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible... without the need for special adaptation or specialised design".*

Its origins date back to the 1960s when a group of designers felt the need to pursue a more socially responsible approach to design. At a time when designers tended to treat people as "universal types" rather than individuals, inclusiveness began to play a central role in the design process. Initially, the elderly and disabled, who did not fit the standards dictated by mass production, were treated as exceptional cases or groups of individuals requiring specialized design solutions. An ugly and ineffective design, however, ended up stigmatizing its users, who felt in the shadow of society.

Terms such as "design for disability" and "design without barriers" began to give way to concepts, such as "Design for All" in Europe, and Universal Design, in the United States. These expressed a more inclusive approach towards people whose requirements should fit into every phase of the design process (Coleman *et al.*, 2007).

Both approaches, born from the design of the built environment and websites, admit, as regards designing product, that it is not always possible for a product to meet the needs of an entire population. However, traditional products should be accessible to as many people as possible (Wolfgang and Ostroff, 2001).

In contrast, Inclusive Design[3], born in the UK from digital technologies in the 70s and 80s, such as subtitles, created by the National Bureau of Standards and ABC, to make TV content accessible to deaf people and audiobooks for the blind, focuses on choosing an appropriate target market for a particular design. While Universal Design is final product-oriented, with expost and not in-progress evaluations of outcomes, Inclusive Design is more attentive to the processes that led the designer to that design and whether they included contributions of excluded communities (Holmes, 2018).

An expression that clearly explains the distinction between the two approaches, coined by Treviranus[4], is this: "*Universal design is one-size-fits-all. Inclusive design is one-size-fits-one*".

A one-size-fits-one approach allows us to find non-specialized solutions and in a digital world like ours, to create a design system that adapts, transforms and extends according to the needs of each individual[5].

Ultimately, with the advent of Inclusive Design, the designer no longer focuses only on a single problem but takes a more holistic approach to socially responsible design. It means that when making decisions about the use of resources, products, places, and communications, the designer must grasp the dimensions of social responsibility (Coleman *et al.*, 2007).

Moreover, the main mistake of some young designers, until recently, was to create products/services, not only not accessible to large groups of users, but that reflected the tastes of a very young market. In fact, it is inevitable to consider the aging process and the possibility of adverse events or accidents that may cause debilitating medical conditions, temporary or permanent disabilities. Anyone can find themselves unable to perform everyday actions. In this regard, some UK design consultancy firms have shown that working with older and disabled people can be challenging to find innovative solutions. Indeed, many innovations result from situations that have excluded users from participating in everyday activities. For example, the multitouch was born with Wayne Westerman, who has severe carpal tunnel syndrome and has developed a method of interaction with the computer without requiring any force in hand.

As also widely discussed by Elise Roy[6], in Ted Talks 2016, when we design for disability, we all benefit from it, because we often come across better solutions than when we design for the norm. For example, subtitles, originally designed to make information accessible to deaf people, are useful to many more people in a variety of contexts and situations. In airports or crowded places, users refer to subtitles to access the news.

Human diversity is therefore not only a resource for better projects but, as defined by Gregor *et al.* (2002), also "dynamic", because it encompasses both the plurality of diversity and its transformation over time. It can be summarized in the expression "It is normal to be different", of Lange and Becerra's (2007) teaching approach, as differences are as a continuum ranging from single to

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multiple disabilities, from differences in gender, culture, to different lifestyles and aspirations. Further aspects of diversity, regarding how normal it is to want different things and to do them differently, we find them in the article "It is normal to be different: Applying inclusive design in industry". The authors, Hosking, Waller and Clarkson (2010), researchers and promoters of Inclusive Design in

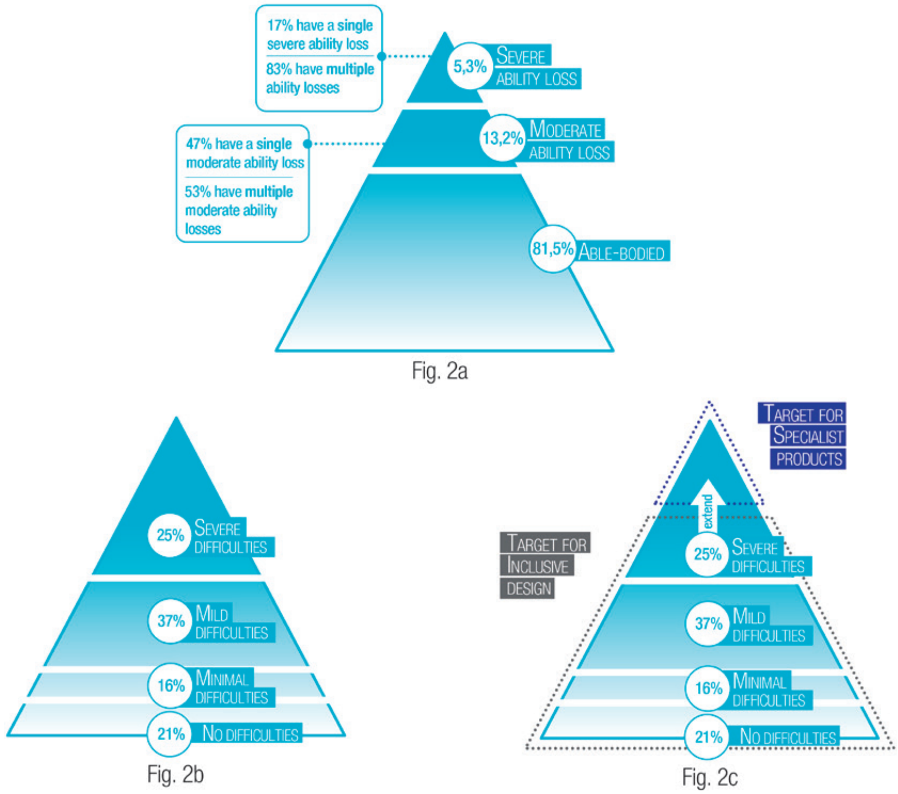

Fig. 2.2 - Graphical reworking of the segmented diversity pyramid model[7] to identify various categories of users. The pyramid shows people without difficulties in the lower segment and gradually, those with more significant difficulties. In Fig. 2a the data, drawn from the 1996/97 follow-up survey on disability (Grundy *et al.*, 1999), highlights the importance of focusing on users with multiple disabilities, passing the analysis of the single disability. Fig. 2b, which reports the data of the Microsoft survey of 2003, shows an alternative segmented pyramid, in which diversity is conceived as a matter of majority and no longer of minority, also considering those less severe levels of difficulty that cannot be associated with any disability. Fig. 2c represents a model capable of showing how Inclusive Design must take into account those who are less capable, extending the reach of traditional products towards the top of the pyramid, without creating disadvantages for the lower levels of the pyramid

industrial realities, within the article highlighted how the pyramid model (Fig. 2.2) makes companies more aware of the problems related to user diversity. It pushes them to consider cases at risk of exclusion to try to redesign inclusively, improving the experience of as many users as possible in various contexts.

An example of a company that has adopted this inclusive thinking, within its development process, is BT: *"Over the past 5 years BT has undergone a major transformation from a company with a special section devoted to "older and disabled consumers" to a company with an inclusive design strategy"* (Chamberlain *et al.*, 2015).

The benefits of adhering to the inclusive approach had already been widely discussed by Keates and Clarkson (2004). In their book, they predicted that Inclusive Design could not be considered an option, but that it would become a corporate requirement because many countries were already introducing legislation against all forms of discrimination.

"Those companies that have embraced inclusive design are reaping the financial rewards. Products designed for inclusivity are designed for usability and accessibility and customers respond strongly to this. Those companies are building strong brand image and brand loyalty and are already leaving their competitors playing catch-up. As customers are presented with an ever increasing choice of accessible and usable products, they will increasingly turn their backs on products that are too difficult to use" (Keates and Clarkson, 2004, Preface).

According to Kat Holmes[8], when we plan for inclusion, we plan for the future and how the next generation will take care of us. Ensuring that the world of the future is genuinely inclusive is possible, in a digital age like ours, where Inclusive Design is good design. However, it is essential to bring young designers/researchers to disseminate examples of good Inclusive Design practices and to design solutions to support the essential human connections in our life, such as health, safety etc. An example is the Microsoft company that developed "A Microsoft Design Toolkit" guidelines to make products for the most significant number of individuals. Their ambition is to create products that are physically, cognitively and emotionally appropriate for each individual.

Susan Goltsman, Inclusive Design leader and mentor of our time, says that: "*Inclusive design doesn't mean you're designing one thing for all people. You're designing a diversity of ways to participate so that everyone has a sense of belonging*"[9].

Many people are unable to participate in certain aspects of society, both for physical and digital issues. In order to make traditional products better and more satisfying to use, the Inclusive Design should be integrated into the design process. It is possible starting from a perceived need that that turns into a solution, according to the "waterfall" model in 4 key phases, proposed by the authors of the "Inclusive design toolkit"[10] (Fig. 2.3):

- discovery: the right design challenge by exploring the perceived needs and considering all interested parties to get to the first output (understanding the real need);
- translation: of the need in well-defined design intents, leading to the second output (the specification of the requirements);
- creation: of preliminary concepts that are evaluated concerning the requirements, leading to the third output (concepts);
- development: detailed design of the final product/service, ready to be produced or implemented; leading to the final output (solutions).

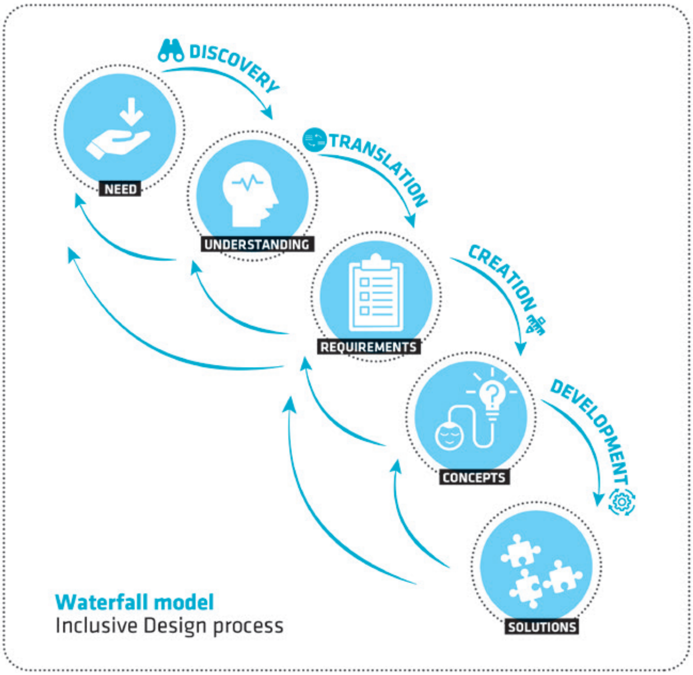

Fig. 2.3 - Graphical reworking of a "waterfall" model of an Inclusive Design process

During the entire design process, the assessments and decisions made affect the level of exclusion of the design. The toolkit, provided by the authors, aims to give knowledge and tools to reduce any possibility of exclusion. By applying the three principles of Inclusive Design (1. Recognizing exclusion; 2. Learning from diversity; 3. Solving for one, extending it to many) by involving users in the design and considering people's needs, the products can be usable, useful and desirable (Clarkson *et al.*, 2007).

The involvement of the user, which implies knowing him, understanding his needs, desires, empathizing with him, in the Inclusive Design process, is essential, as the user can only be considered the essential component in any system. Real users, within the design process, are fundamental and cannot be replaced by simulators (wearable devices and software), which reduce sensory and physical abilities but do not simulate pain and how over time we can adapt to the loss of capacity (Hosking, Waller and Clarkson, 2010).

Therefore, many researchers and designers, nowadays, wonder how it is possible to interact with the user to understand the experience. Adopting an empathic approach allows a holistic understanding of users, who can join the design team as experts of their own experience. Therefore, interaction with the user lays the foundations for a co-creation process, which favours Human-Centred Design. Many times the design approach of companies is instead focused on technology and/or on the brand. In reality, Inclusive Design practices should be centered on the user and man-product interaction (Keates and Clarkson, 2004).

In this regard, an approach that clearly expresses the centrality of the user is that of Human-Centred Design (HCD) seen as *"an intervention philosophy that aims to develop products/systems or services that can satisfy people's needs, so that interacting with them is characterised by a high level of usability and ease of understanding and can offer a user experience that is positive and satisfying"* (Tosi, 2020, p. 112).

The concepts that will be treated within this section (Fig. 2.4) relate to the topics addressed so far. All the contributions that follow highlight the centrality of the user in the Inclusive Design process, seeking to improve the User Experience. The various professionals conducted research, using the following design approaches Human-Centred Design, Universal Design, Design for Ergonomics, Design Thinking, User Experience and Open Source Design. The results emerged are the consequence of the application of various design methodologies such as cognitive surveys, direct observations, interviews, questionnaires, surveys, audio-video recordings, focus groups, mapping of experiences with the involvement of users and professionals.

Specifically, the research deals with:

- **accessibility** in terms of access to public and urban facilities, as well as the use of products accessible to multiple users;

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- inclusive solutions for visual, hearing, motor and neurological **disabilities** (SLA, limb amputation) using open source design and services for students with disabilities (DSS);
- education on the concept of **care** in design, management of care (hippotherapy, diabetes) and risk reduction in therapies, for example through remote telemonitoring systems;
- optimizing the **orientation** experience within the school and urban context, through inclusive navigation apps and assistive devices, able to create customizable paths and to store them;
- **usability** and **ergonomic analysis** concerning mobility systems for hippotherapy and workstations;
- creation of **empathy** in the design process, through "role-playing games" and "living laboratories" in a series of co-creation platforms.

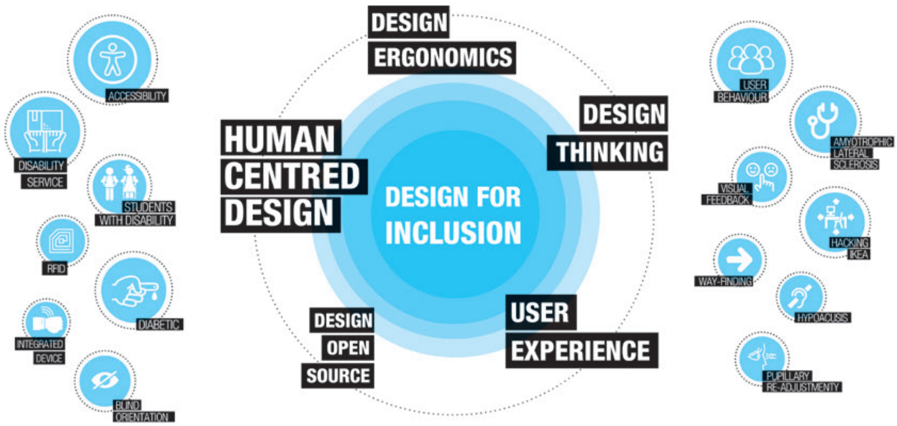

Fig. 2.4 - Keywords on the topics covered in the Design for inclusion session

In conclusion, we can say that Inclusive Design plays a decisive role in improving the lives of the individual, going far beyond the design of a product/ service. It has a social responsibility that implies a change of mentality, action and methodologies. An excellent Inclusive Design opens new challenges to changing our culture and future, making the whole design process more human and aware.

Notes

[1] https://sites.google.com/view/pudcad-conference-unifi/home.

[2] www.inclusivedesigntoolkit.com.

[3] Jutta Treviranus and her team at the Ontario College of Art and Design founded the Inclusive Design Research Centre in 1993 to focus on ways that digital technology can improve social inclusion.

[4] For further information, visit the website of the Inclusive Design Research Centre at OCAD University: https://idrc.ocadu.ca/.

[5] Elise Roy's speech at the TED Talks 2016: www.youtube.com/watch?time_continue=7andv=g2m97gPI70Iandfeature=emb_logo

[6] Info on www.inclusivedesigntoolkit.com/whatis/whatis.html.

[7] Kat Holmes, named one of Fast Company's "most creative people in business" in 2017, is the founder of mismatch.design, a company dedicated to Inclusive Design resources and education. At Microsoft from 2010 to 2017, he led the company's executive program for inclusive product innovation. In 2018, Holmes joined Google and continued to promote the inclusive development of some of the world's most influential technologies. She is the author of Mismatch: How Inclusion Shapes Design.

[8] Quoted in Inclusive, a short film by Microsoft Design; www.mismatchmedia.com.

[9] Commissioned by BT and developed in partnership with the i~design research team.

[10] Graphic reworking of the following source: www.friendshipcircle.org/blog/2014/01/02/inclusion-what-it-is-and-what-it-isnt/.

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3. Designing an Inclusive Navigation App for Taşkışla Building

by Ozge Cordan, Demet Arslan Dincay, Cagil Yurdakul Toker, Elif Belkis Oksuz, Sena Semizoglu

Abstract

When it comes to inclusiveness and "caring for the individuals" needs, design partakes a social responsibility in all disciplines. "Design for All" motto is not only for the acquisition of Universal Design principles, but also for providing a better User Experience for every individual everywhere, in any kind of platform. In this context, our study presents the process and outcomes of a student workshop as preliminary study of a startup project; an indoor navigation app for school environment. Aim of this application is directing people with special needs towards best alternative routes in complex buildings, which can be personalized for user's physical abilities to improve their way-finding experiences. Workshop was conducted with participation of interior architecture students from 3rd year and workshop instructors with different majors After a short brief about the User Experience design, students were first asked to create their personas with a special need, pick locations for different scenarios. Following the paper prototyping technique, students used template for device, sticky notes, sketching and coloring materials to visualize their ideas. Working as groups of 7, the students were asked to present their ideas in five boards to be placed in their device templates. Their works were evaluated through User Experience, Universal Design principles as well as design Ergonomics considering the use of graphic language selection and other sensory experiences.

Keywords: *Inclusive Design, User Experience, Design education.*

3.1 Introduction

Inclusive Design is a movement that has encouraged designers to extend their design briefs to include everyone (Newell *et al.*, 2011). "Design for All" motto is not only for the acquisition of Universal Design principles, but also for providing a better User Experience for every individual in everywhere in any kind of platform in this point of view User Experience is the most important urge for designer to create for all.

For a typical User-Centred Design, the process might include five phases: understanding users, tasks, contexts; design; prototype; evaluate and integration and final implementation (Petrie and Bevan, 2009). Design process which includes and leads these phases might end in friendly environments by practicing/following Universal Design principle. Designers should improve the main design idea due to the users' needs and potentials with a realistic point of view. Brown (2008) describes Design Thinking as an approach of human-centered innovation that uses the designer's sensibility. At this point, designing for people with special needs, empathy is the most important and essential step of all design process (Brown, 2008).

People with special needs may have an adequate environment in their home space, but it's hard to say if outside environments and public spaces has the equal conditions. They often frustrate in daily life since there are lots of public spaces which are not designed by following the Universal Design principles. At this point, today's technology can and should help these special users to be prepared for possible physical obstacles in a public space to endure a social life.

In this context, this paper presents a workshop which aims to give a learning experience to Interior Design students about way finding/navigation in a space for people with special needs as well as emphasizing how a designer's role and knowledge needs to expand to different platforms when it comes to designing user-friendly environments by practicing/following Universal Design principles. The workshop is a preliminary study of a start-up project, an indoor navigation app for complex buildings which will be used for directing people with special needs towards the best alternative routes in a building, which can also be personalized for user's physical abilities to improve their wayfinding experiences. Through mentioned workshop, this study aims to raise awareness of design students about Universal Design principles, user centered design and also User Experience factor in design process for public spaces.

3.2 Background

People have ability to orient in familiar environment. However, if they are in completely new environment or they have unexpected challenges in the familiar spaces, they would look for any help which shows the way. Indeed, architecture plays an important role to allow people draw a mental map of the environment. That is to say, layouts should be clear, pathways, visual cues and landmarks should be well defined (Allen and Chudley, 2012). Unfortunately not all buildings are designed accordingly. Especially, the historical buildings those are remodeled with the adaptive reuse scenarios might have confusing layouts for a newcomer to understand how to navigate inside. Even if the user is not new in the environment, he/she may have an unexpected challenge or special needs that would lead her/him to think from another perspective for finding the way. Therefore, people would use the help of wayfinding, signage systems, printed maps or someone to ask and finally digital technologies.

Designers have detected this problem and developed some applications for indoor navigations. The most wellknown ones are Maze Map, NavVis. They are indoor maps and wayfinding platform which use different technologies to update the indoor positioning. Nevertheless, they didn't target the people with special needs while developing these applications. These apps work very well for the ones who is confused and doesn't know where to go. But, they fail for the ones with special needs who might need another path to follow that would require the shortest route with elevator or ramps, etc. Thus, the app should allow users to personalize their user selection depending on their needs and show the route options accordingly. It should also update the people flow, potential obstacles frequently and recalculate the routes and show the best options.

At his point, knowing about the Universal Design principles and the users, as well as their requirements play an important role. For these, the core principles of Universal Design should be considered and wayfinding systems should be designed following these principles.

First principle is equitable use. This means wayfinding design should in use of all users without any segregation. It should provide platform for any kind of users.

Second principle is flexibility in design. The whole system should provide adaptability to user's preferences and abilities. This could be solved with various types of medias which allows users to listen or read.

Third one is simple and intuitive use. The design should be easy to understand regardless the user's background, skills, age, etc. The information system and interface should be clear without any unnecessary complexity.

Forth principle is perceptible information. The system should provide necessary information in an effective, recognizable and direct way via multiple senses. Tips, clues and additional information would be useful.

Fifth principle is tolerance for error. Information systems shouldn't cause any harm, it should warn for the errors.

Sixth one is low physical effort. Users should reach any information with a minimum of fatigue and stress.

The last but not the least principle is size and space for approach and use. Right size, height and space should be provided for the users' mobility and access (The Center for Universal Design, 1997).

After understanding the core principles, potential users and their requirements should be studied by using User-Centred Design methods. Because a product can bring success only if it provides a good experience for the targeted users (Allanwood and Beare, 2014). First of all, creating personas for the intended users would help to understand users' potential choices depending on their age, ethnicity, gender, ability, special needs, income level, language, education, occupation, etc. Writing down a design scenario with fictional personas would lead designers to empathize with their users (Allen and Chudley, 2012). Including people with special needs to user group can be problematic to use the right information. According to Newell *et al.* (2011), the use of theatre is a powerful method to communicate message between designers and users if the targeted user group includes people with disabilities. Thus, empathy experience would also work for designers to perceive and find out the difficulties, constraints of the people with special needs. Empathy experience can be designed as a part of requirement workshop. User requirement workshop is a hands on decision making method that is used for illustrating the project outcomes, understand users' needs with a small project team. During the workshop team would work with different methods such as user-journey mapping, card-sorting, wire framing, paper prototyping (Allen and Chudley, 2012). Mapping works for simplify the experience and making the goal more visible by representing visual connections. Card sorting method help people to organize and categorize the activities, requirements, tasks, etc. (Goodman, Kuniavsky and Moed, 2012). On the other hand, working with wireframes or concept sketches would uncover the structure of the application while paper prototyping would give concrete ideas about the final product and its usage. Even though it is a low fidelity approach in User Experience design, it helps designers to find out about the size constrains.

As described, designers should know more about what is Inclusive Design, what are the requirements of people with special needs and work on the manual or digital solutions to make their daily lives easier.

3.3 Methods

A one-day workshop was organized to define the user requirements to understand how to navigate in Taskisla Building, as the feasibility study for the mentioned app. As the first step, workshop aimed to explore User Experience design and Universal Design principles through app design. It was conducted by PUDCAD-ITU team at the building of ITU Faculty of Architecture with the participation of ITU interior architecture students from 3rd year and workshop instructors with different majors such as game designer from BAU.

Before starting, students were informed about the aim, similar studies, some theoretical background and methodology. They formed 7 groups with 5 members. Each group were asked to think about for who this app would be designed, for what reason, context, where it can be used, when and why it would be needed (Roberts, Headleand and Ritsos, 2017).

Workshop was planned to have six steps: persona selection/gamification, walkthrough experience, ideation/brainstorm session with Sketching drawing materials, paper prototyping, realization and finally presentation.

Persona Selection/Gamification: students were asked to create their own users and scenarios depending on the user's requirements. They created an actual user with name, age, gender, occupation, lifestyle and all other definitions. Then they chose one challenge among many challenges for their users. These challenges were carrying some bulky stuff, cannot hear, cannot see, cannot differentiate colors, cannot walk (crutches), cannot walk (wheelchair), cannot talk (language barrier).

Walkthrough Experience: each group were invited to have an empathy experience related to their challenges and scenarios to find out the potential frustrations. Thus, adapting themselves the chosen challenge with the help of some tools, they tried to navigate in Taskisla building without any help.

Ideation/Brainstorm Session: until this phase, each group finished their walkthrough experience and listed the frustrations they faced during their experience. They made a research through Inclusive Design to understand the requirements as well as to design accessible apps. They generated as many solutions and ideas as they can in a limited time and in the end, they formed their final concept within these ideas. They worked on developing a logical path for their users and planning their journeys by asking how would they run the app and use it, navigate between the contents using wireframe and cart sorting method.

Paper-Prototyping: a laser cut cardboard phone prototype was given to the groups in order to test how their app looks an actual screen size. Students worked on their sketches using this pattern and prepared the paper prototype for their app.

Realization: after finishing working on their paper prototypes they conveyed their idea to digital platform. Before the workshop, students were advised to download Balsamiq software in order to use during realization phase.

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They were given a quick introduction to the software and design their app on the program.

Presentation: each group presented and download their idea on a shared digital platform. They walked juries through their user journeys. The critics were given during the presentation.

3.4 Results

Group 4,5: their challenge was the color blindness. Students created a persona, an 18 years old boy who has just been accepted to ITU Faculty of Architecture (Fig. 3.1). As their persona specially needed to differentiate colors, group focused on the color contrasts not only on the screen but also on the path that user should take on the way. They followed two strategies; first, they chose the colors for the app which are suitable for almost all types of color blindness. Second, they chose the landmarks those might create the highest contrast to be used as check points. The opening screen of this app gives users two options; reach and discover. Option reach takes you from one point to another while the other option gives you an orientation tour around the building supporting it with mini quiz.

Group Cortado: this group had a 19 years old, female architecture student as the persona (Fig. 3.2). The challenge they chose for their persona was the wheelchair. App has a simple design with color coding concept. User can choose their special needs on the user selection screen. It would update users about the exhibitions and events going on the corridors as they could be an obstacle. It would show the best path with alternatives, it also has sound control which would give users instructions.

Group Touchkisla: their persona is 19 years old, computer engineering student with vision impairment (Fig. 3.3). First of all, group suggested Taskisla building needs to be installed with braille alphabet and signage system. The

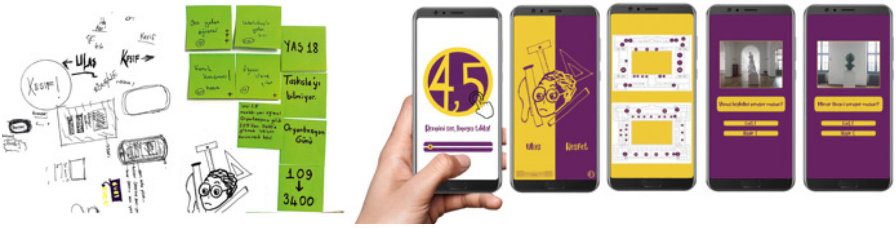

Fig. 3.1 - Group 4,5: process and app design

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app has sound activation system and it gives instruction to the users. It would be updated about all of the events and exhibitions going on. The cam works as warning tool that beeps and vibrates when user comes close to an obstacle.

Group FYW: their persona is 20 years old student who comes to Taskisla for handing over a big scale model to her friend (Fig. 3.4). The app works by tapping on the screen. Group aimed this app to be used by everybody. So, when users run the app they can personalize it depending on their special needs. It has the voice activation and uses vibration to warn users; one buzz means that they are on the right way, while continuous buzz means that they are on the wrong way.

Group Fugitive: their persona is a design students with mobility limitation; se recently breaks her leg and needs to use crutches (Fig. 3.5). User can per-

Fig. 3.2 - Group Cortado: process and app design

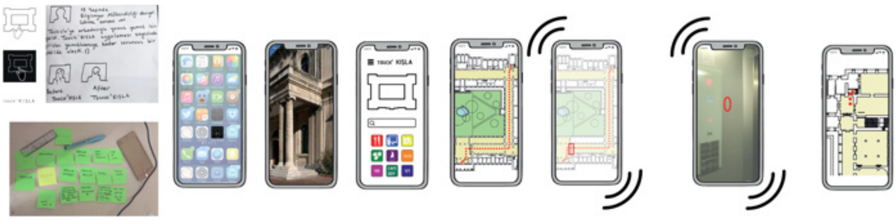

Fig. 3.3 - Group Touchkisla: process and app design

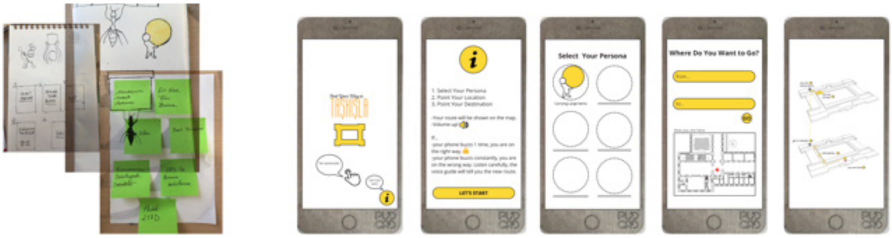

Fig. 3.4 - Group FYW: process and app design

sonalize their personas from the user selection screen, then app takes users to language selection option. Users can activate the sound activation system if they want. App shows users the optimal route along with the number of estimated step count, time and distance.

Group Mapsitu: persona they created is a foreign guest who comes to Taskisla for a conference and looking for the conference hall (Fig. 3.6). But to do that first he has to communicate with the security at the front desk. Opening screen of the app comes with the language selection. Then users can choose the spaces where they want to go. But the difference what this app offers to the users is connecting them with the students whoever is free at that moment and willing to help. Thus, users and assistant students can chat on the digital platform in order to reach the space.

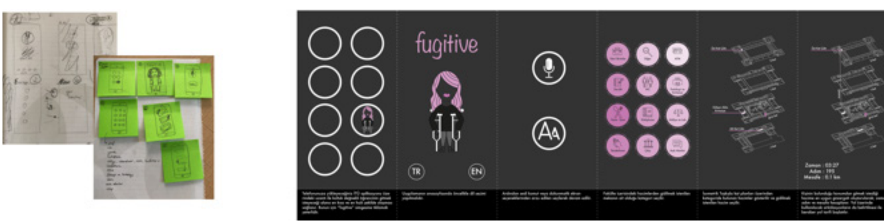

Fig. 3.5 - Group Fugitive: process and app design

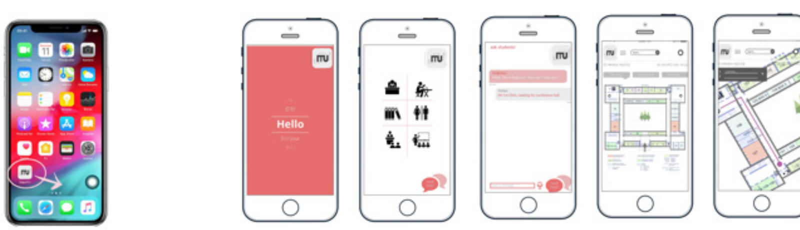

Fig. 3.6 - Group Mapsitu: process and app design

Fig. 3.7 - Group Yougo: process and app design

Group Yougo: their persona is 18 years old, design student just registered. He is hearing impaired after an incident (Fig. 3.7). The app gives you an opportunity to personalize your user selection depending on your special need. After choosing the persona, users should choose the place they want to go among the listed names or from the search bar. After choosing the place a screen opens and leads users with sign language. It shows also the layout and route along with the information of remaining time, estimated number of steps. The trip goes on with the signs of the sounds around to make users feel the atmosphere.

3.5 Conclusion

As a conclusion, "awareness of inclusive design" may define the major gaining of this study. Interior Design students who are future designers are informed and felt empathy for people with special needs. Students not only re-experienced the familiar school building through their persona's point of view but also combined existing spatial experience about Taskisla with their sensory abilities.

Workshop presented the Interior Design students a chance to design and gain experience in a different field. App design is a big challenge for them by its own principles. At this point, it was a great experience for Interior Design student who had worked with the guidance of software designers. Workshop included the step of paper modelling similar to Interior Design process. It's certain that, app design/using experience design has its own steps of practice but this approach helped student to understand how to work with media tools. Students realized that Universal Design principles could also inurement and necessary for digital technology field.

At the end of the workshop, conceptual app proposals were presented, since students designed the applications in limited time with interior architects point of view. Despite the fact that almost on all proposals architectural layouts were used and they might require an architectural background for using, all of them were evaluated as improvable designs from tutors.

It's foreseen that, workshop will carry through in a second phase with digital media design students and complete the Taskisla navigation app including all related disciplines. It is believed that this study will create an awareness and similar aps would help to provide more and more technological supports for people with special needs in public life.

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Notes

[1] PUDCAD (Practicing Universal Design Principles in Design Education through a CAD-Based Game) is an Erasmus Plus project that has been carried out to inform, update and allow design students to adopt Universal Design criteria for schools while practicing it simply with a CAD based game. PUDCAD partners are: ITU (Turkey, Coordinator), LIPPE (Germany), LAMK (Finland), UNIFI (Italy), POLIMI (Italy), the "Association for Well-being of Children with Cerebral Palsy" (Turkey) as well as the "Occupational Therapy Association of Turkey".

[2] Balsamiq is a low-fidely wireframing software to be used for UI design. It can be downloade for free on https://balsamiq.com.

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4. Accessible Services for Students with Disabilities

by Hülya Kayıhan, Onur Altuntaş, Meral Huri, Gonca Bumin

Abstract

Universities have an important role in providing good employment opportunities and social status to students with disabilities. Therefore, in order to ensure the full participation of students with disabilities in university life, universities should be accessible in all areas. Universal Design refers to the design and composition of an environment which can be accessed, understood and used by all people, regardless of their age, size, ability or disability in the greatest extent. Universal Design focuses on the design of products, buildings, or environments so they can be used readily by the widest possible range of users. Hacettepe University provides equal and integrated access for students with disabilities to all academic, social, cultural, and recreational facilities which are offered according to Universal Design principles. The organization of all necessary arrangements for equal and integrated access of disabled students is provided by the Disabled Student Service (DSS) at the university. Two hundred and eight students with different disabilities (blind/low visual impairment, physical disabilities, deaf/hearing impairments), mental health problems, long term medical conditions (cardiac problem, epilepsy, diabetes), specific learning difficulties are enrolled in this service. The DSS is also the first point of application for all students with disabilities. This article aims to explain the services provided by our university to all students with disabilities.

Keywords: *Accessibility, Disability services, Students with disabilities.*

4.1 Introduction

The presence of inclusive schools in primary and secondary schools and participation in the least restrictive learning environment contribute to the increase in high school completion rates and expectations for post-secondary education for students with disabilities (Brinckerhoff, McGuire and Shaw, 2002).

The increase in reading proficiency, the increase in the number of students with disabilities who have graduated from high school and the decrease in drop-out rates encourage disabled students to continue their education in the post-high school period (United States Department of Education, USDOE). These positive results provide opportunities for better preparation for the college and the number of students with disabilities who continue to higher education (Burgstahler and Moore, 2009).

In Turkey, special education services for the students with disabilities have been expanded and the number of students with disabilities in primary and secondary education has increased in the last 10 years. The majority of students with disabilities in primary and secondary education receive education in schools where mainstreaming practices are conducted with their normally developing peers. As the enrollment rates of disabled students increase, there is an increase in the number of students wishing to continue to higher education (Higher Education Institution, Barrier-Free Access Workshop, 2017).

Responding to the needs of students with disabilities in the school setting requires a comprehensive, coordinated, and systematic approach. Students with disabilities can function to their maximum potential if their needs are met (Students With Chronic Illnesses: Guidance for Families, Schools, and Students). Providing effective academic services for students with disabilities demands among other thorough planning, appropriate organizational scheme, human resources with specific expertise, advanced assistive technological support, considerable implementation effort, and functional evaluation (Kouroupetroglou, Pino and Kacorri, 2011). In order to provide all these services correctly, the university environment should be accessible to everyone (Vijayalakshmi and Sequeira, 2018).

Environmental design is a determinant of social inclusion and people's participation in life roles. Universal Design refers to the design and composition of understood and used by all people, regardless of their age, size, ability or disability to the greatest extent. This approach proposed 7 principles for designing buildings. These principles were equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort and, size and space for approach and use (Watchorn *et al.*, 2014; Steinfeld and Tauke, 2002; Connell *et al.*, 1997). Universal Design focuses on the design of products, buildings, or environments so they can be used readily by the widest possible range of users (Rose and Gravel, 2010; Winzer *et al.,* 2018; Wizikowski, 2013).

Hacettepe University provides equal and integrated access for individuals with disabilities to all academic, social, cultural, and recreational facilities which are offered according to Universal Design principles. The Disabled Students Services (DSS) supports and helps the disabled students by creating an accessible and inclusive campus. Finally, this paper aims to present the services offered to students with disability.

4.2 Participants

Enrollment in the DSS depends only on the student's self-definition. The student with disabled cannot receive this service unless he / she apply voluntarily. Two hundred and eight students with various disabilities; total/low visual impairment (46 students), physical disabilities (30 students), hearing impairments (42 students), specific learning difficulties (10 students), long term medical conditions – epilepsy, diabetes, cancer – (50 students) and mental health problems (26 students) study in our university and students with temporary injuries (4 students) apply to DSS.

4.3 First Step to University

Accessibility and orientation training is given to all students with disabilities who are new to our university at the beginning of each year by the DSS. During the orientation week, campus presentations are organized according to a structured program prepared by the university. During this week, students with disabilities are accompanied by volunteer (peer) students. Upon the request of the disabled student, this voluntary (peer) student support continues until graduating from the university. Volunteer (peer) students provide support to students with disabilities in studying, preparing for exams, participating in activities, and adapting to campus life.

4.4 During University Life for All Students with Disabilities

Individual interviews are made with the students with disabilities from the team of DSS. In these interviews, our students are evaluated by an interdisciplinary team in terms of skills, academic performance, accessibility requirements, participation, roles, goals and satisfaction perceptions. According to the results obtained, a suitable client-centered support program is prepared and implemented for each individual with disability. These evaluations are reviewed at the end of each year and the program is revised according to changing situations.

Occupational Therapy Department is coordinating the DSS in collaboration with the university hospital, medical school and department of occupational-therapy, physiotherapy, audiology, language and speech disorders additionally to the guidance of research centers.

These opportunities provided for every student who needs education, rehabilitation and counseling services to increase their quality of life, career development and community participation.

In our library, there are screen readers, scanning and reading Software, OCR Scanning Software and audiobook archives. Our library is accessible for all students.

4.5 Implementation for Students with Blindness or Visual Impairment

For students with blindness or visual impairment, the DSS maintains an online list of major buildings with access points, including audible crosswalks. It is located on the guide roads to ensure accessibility within our university.

Mobility orientation training is given to visually impaired students. Each student is provided with computers that support screen reading program such as JAWS. Classrooms, labs, libraries, cafeterias, housing, and transportation is accessible. Guideways and elevators are used to provide accessibility. Assistive technology room and additional support (assistive technology, adaptive equipment or software for the library) is available.

IThere are screen readings and magnifying software, speech prediction, JAWS programs, closed-circuit television to magnify reading material, PCs with large screen monitors and accessible work stations in our library.

4.6 Implementation for Students with Physical Disabilities

For physically disabled students (such as paraplegia, hemiplegia, amputation, congenital hip dislocation, brachial plexus's injuries), the DSS coordinates the work to ensure accessibility to all areas of the university environment.

The DSS maintains ramps, elevators and stair elevators are used to provide accessibility. Appropriate arrangements are made for the free movement of wheelchair students in the classroom such as removal of the queue. At the same time, necessary arrangements are made in the toilets that are easily used by disabled people.

4.7 Implementation for Students with Deafness or Hearing Impairments

For physically disabled students (such as paraplegia, hemiplegia, amputation, congenital hip dislocation, brachial plexus's injuries), the DSS coordinates the work to ensure accessibility to all areas of the university environment. The DSS maintains ramps, elevators and stair elevators are used to provide accessibility. Appropriate arrangements are made for the free movement of wheelchair students in the classroom such as removal of the queue. At the same time, necessary arrangements are made in the toilets that are easily used by disabled people.

4.8 Implementation for Students with Learning Disabilities

For these students (such as dyslexia, dyscalculia), awareness trainings are given to educators especially in writing exam questions clearly and not using abbreviations. In these trainings, during the lesson, there should be written explanations as well as diagrams, thinking time should be kept longer in speaking/listening exams, not to be forced to respond quickly in discussion groups.

The DSS also provides training in writing and reading skills, time management, self-management skills, problem solving skills, memory and attention development.

4.9 Implementation for Students with Chronic Diseases

The DSS can work together with lecturers, students, health care providers to provide a safe and supportive educational environment for students with chronic illnesses and to ensure that students with chronic illnesses have the same educational opportunities as do other students. The DSS first informs the counselor of a chronic illness student about his/her symptoms, concerns and needs in the school environment.

There are two hospitals on two separate campuses of Hacettepe University. Students apply to these hospitals for any health problems. There is also a Blue Code application (Call 2222) for people with health problems on the university campus. When this number is called for the person with health problems, the doctor and nurse are directed to the person as soon as possible.

4.10 Implementation for Students with Mental Health Problems

The most common mental health disorders among students are depression, attention deficit disorder or attention deficit hyperactivity disorder, anxiety, obsessive compulsive disorder, and eating disorders. Our university has many resources available to students to help with diagnosing and treating most issues. It is important to implement these resources into a student's education plan. Students sometimes hide their illness to avoid being stigmatized as disabled. Teachers' knowledge of warning signs of mental illness is important in identifying and encouraging these students to receive support. Sometimes, peer student support is important in ensuring that these people express themselves. Thus, it can be ensured that this person is referred to DSS and receives the necessary treatments. In Occupational Therapy Department, students are given training on social skills training, self-management skills training, identifying the activities that are important for them, increasing their motivation, and coping with stress strategies. This department also provides consultancy services for career development and vocational rehabilitation.

4.11 Participation in Social Life at the Unıversity for All Students with Disabilities

Adaptive sports, recreation, and other on-campus activities such as concerts, spring festivals, events organized by the student communities are accessible. It is ensured that every activity to be carried out in our university is accessible. Announcements about all activities at the university are made available to all students with disabilities (such as to write Braille alphabet for blind students, sending the announcements with mail/message for hearing impaired students, large points for students with low vision). At the same time, student communities are promoted at different events and students with disabilities are encouraged to participate in these communities. Providing peer student support to students with disabilities in participating in out-of-city trips organized by the university is another service provided by DSS.

4.12 Conclusion

The education of every individual is necessary for the continued progress of society. Removing barriers will support social progress. With all these practices, we aim to ensure the full participation of all students with disabilities in university life and to improve social inclusion.

In order to increase both physical and information accessibility, it is thought that constructive studies in other universities will provide significant support for university students with disabilities to participate in university life. It is considered that providing training to academic staff on the use of technological equipment to increase accessibility will have a positive effect on the participation of disabled students.

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5. Incorporating "Care" into Design Education Through Games

by George E. Torrens, Ying Jiang, Hua Dong

Abstract

"Universal Care" can be regarded as the ultimate goal for Universal Design. It implies that design takes care of not only the user, but also the environment, and all other people directly or indirectly influenced by the design. However, "care" as a concept is not necessarily recognised or incorporated in existing design education.

In order to understand what "care" means for design education, the authors have developed two models: the "care" model addresses an Interior Design context, mapping the designer, the client/design, and the environment, to care-giving and care-receiving roles; the "relations" model shows the overlapping between Client, Design object, Design and Environment, for a product design context.

Subsequently two case studies ("My home" and "VI Boccia grid") were presented to illustrate how the models could inform Interior Design education and accessible product design innovation. The game "My home" enabled the Interior Design students to have a detailed conversation about the client's needs and family relations, thus helping raise the designer's awareness of care. The "VI Boccia grid" is a game designed for visually impaired people, and the whole design process highlighted issues critical for the success of accessible product development. Design educators, students, design researchers and practitioners can learn from the two models and the two case studies when applying "care" in their design process.

Keywords: *Interior Design, Care, Game, Sustainability, Universal Design.*

5.1 Introduction: Creating a "Care" Model

"Universal Care" in a design context implies that design takes care of not only the user, but also the environment, and all other people directly or indirectly influenced by the design. It transfers caring from the designer to the user (through "the design") and makes people be more caring to their environment and to other people. This can be regarded as an ultimate goal for Universal Design.

However, existing design processes, design purposes and design methods do not necessarily embrace the core value of "Universal Care", or "caring for all". Although many designers have been educated to "design for needs", they tend to treat "meeting needs" in isolation, and created designs with negative effects. e.g. lack of sustainability or even dangers for "unintended" users. The impact of design can be revealed by viewing design as an act of creation: everything that is created requires something else to be changed, destroyed, or depleted (Fry, 2009), leading to an unsustainable future. Therefore, taking "care" is important for design, and only with "universal care" can we develop ethical, inclusive and sustainable designs benefiting all people and the environment.

While "care" as a concept is widely used in other disciplines (e.g. Nursing), it is not well-recognised in design. In order to understand how the notion of "care" is perceived and practised in design, the second author of this paper conducted a pilot study in Hong Kong, involving 16 interior designers, 17 clients of various Interior Design projects. The main finding was that "care" had been understood and implemented at different levels by interior designers, consciously or unconsciously. A model was developed to help describe different levels of care in a typical Interior Design project.

The model is composed of four key elements, i.e. the designer, the client, the design (i.e. interior space), and the environment (Fig. 5.1).

At the lowest level of care, the designer only cares for self and no other elements; at a reasonable level of care, the designer cares for the design, and the design cares for the client; and the optimal level of care is achieved through the mutual interaction between the four elements, achieving "complete care". The

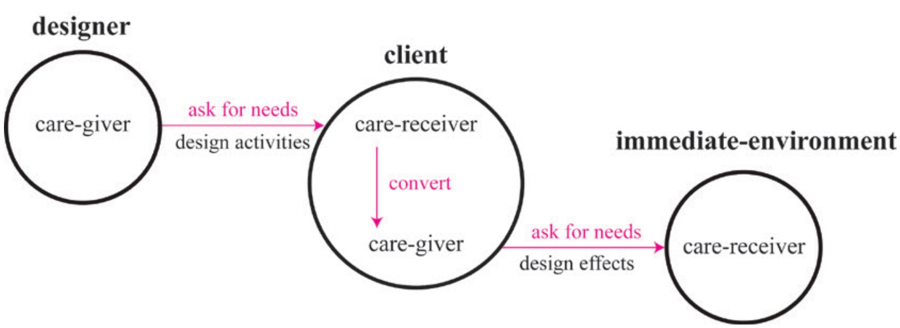

Fig. 5.1 - The "care" model. Modified from Jiang (2019, p. 133)

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process of transforming the designer to a caregiver who turns the client/interior space from a care-receiver to a caregiver is regarded as "Universal Care", an ethical, inclusive and sustainable design approach.

5.2 "My Home" Case Study: Developing and Evaluating a Game for Interior Designers

The proposed care model inspired us to develop a new way of educating interior designers: an interactive game "My Home" (Fig. 5.2).

"My Home" consists of three components, i.e. a map of the home space (typically with a sitting room, a kitchen, a bath room, several bedrooms and storage spaces), a set of daily activity cards (e.g. cooking, bathing, watching TV, dining), and colour labels of family roles (e.g. mother, father, son/daughter, grandparent). The game is played by pairs – typically there is a designer role and a client role within the pair (The pair may have two students or more, as long as they are divided as two parts: "the designer" and "the client").

First, the pairs are introduced the rules of the game and the method of play. The students who play the role of the clients are asked to fill in their family members' basic information, to place the coloured labels on the family tree provided; each colour corresponding to one family member. In addition, they are also asked to briefly report their family members' habits and "likes and dislikes". Second, the paired students are asked to pick a daily activity card in alternative turns until each student had 8 cards (half of the set). Then, one student draws

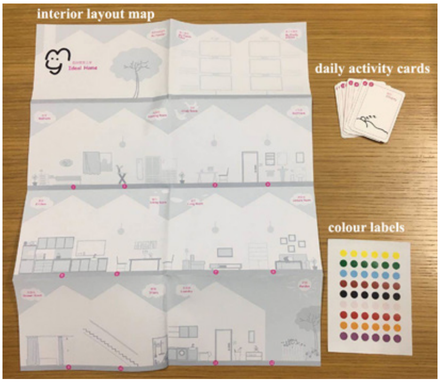

Fig. 5.2 - The "My Home" game with its components (Jiang, 2019, p. 203)

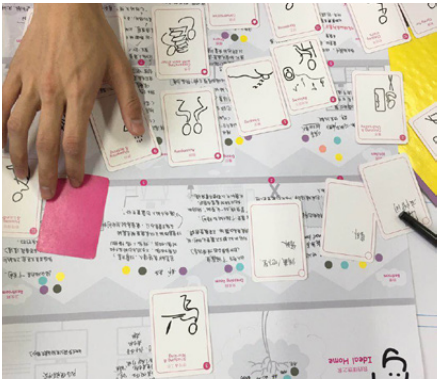

Fig. 5.3 - A piece of completed map and daily activity cards (Jiang, 2019, p. 209)

a card from the paired other, place it on the map, and start to have a conversation over the specific activity displayed on the card. When the game is over, the map will be filled in with notes and sketches (Fig. 5.3).

During the process, the students will discuss a range of issues (prompted by the cards, roles and spaces), developing their understanding of the real needs and the relations between people involved in the future environment, thus becoming more aware of the context and more prepared for addressing the needs, the relations, and the context. The core value of this game is to support the "designer" to help the "client" care about their families and environments. During the game, the "client" has the chance of becoming a caregiver.

The game "My Home" was tested with three groups of interior designers through a workshop (Figs. 5.4, 5.5). Before the game, the participants were interviewed about their understanding of care. During the game, each pair of the students (Participants A and B; Participants C and D; Participants X and Y) was observed through video recording (upon permission) and notes taking.

Figs. 5.4, 5.5 - The game evaluation workshop (Jiang, 2019, p. 211)

The recording included the conversations between the participants, their interactions during the game, and text notes and sketches. For example, Figs. 5.4, 5.5 show the recorded interaction of one group, and their map at the start of the game (on the left, almost empty) and near the completion of the game (on the right, almost full). The conversations were fully transcribed.

After the game, the participants were interviewed again to see whether their understanding of care had been enhanced through playing the game. Those who reported an improvement were asked further questions to understand the reasons. The interviews before and after the game were voice recorded (upon permission) and fully transcribed into texts. The text transcriptions were emailed to the participants for checking accuracy.

The comparison between the interviews before and after playing the game suggests that four out of the six participants had an enhanced understanding of care after playing the game, and the other two indicated little change of understanding. The changes were reflected in three aspects: i.e. the subject, the scope and the context.

1. The change of the subject of care: from “artefacts” to “people”. Participant D regarded “care” as designers’ providing convenience to people’s lives through their design. After playing the game, she started to understand care as caring for people; and design does not only provide convenience to people but also helps improve people’s relationships.
2. The change of the scope of care: from “special groups” to “all”. Before the game, Participant X thought the subjects of care were disadvantaged groups such as disabled people, elderly people, or children. After the game, he realised that everybody needed care and the subjects for care should be beyond special groups.
3. The change of the context of care: from “designing” to “living”. When the student participants were asked about their understanding of care, they tended to answer this question from the perspective of design, and to interpret care from their knowledge of design. After playing the game, they tended to understand care within the context of home and the “living” contexts.

Universal Design has principles and methods, but the key is to make people (clients, designer and users) be more “caring”. The “My Home” game has demonstrated that it is possible to make the clients and the designers to be more aware of the issues of care in relatively short time, a positive step towards “universal care”.

5.3 Associating the “Care” Model with Accessible Product Design and New Product Development

The “care” model (Fig. 5.1) was proposed in the context of Interior Design. By associating the four key elements with product design, a “relationships” model was developed (Fig. 5.6), with reference to the relationships between assistive technology and design disciplines (Torrens, 2018, p. 67). The “relationships” model suggests the complexity of developing assistive technology

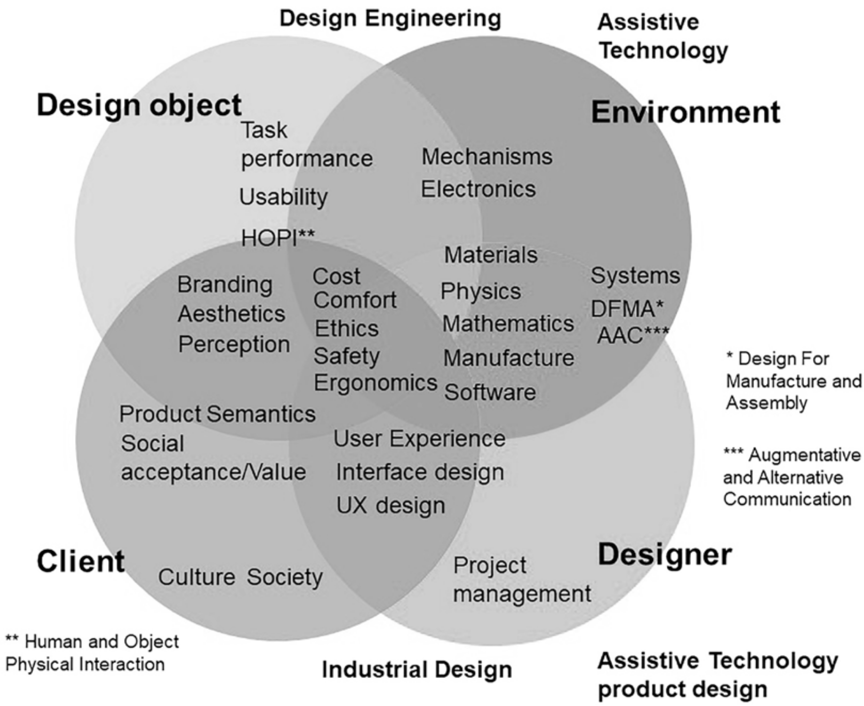

Fig. 5.6 - The "Relationships" model: Client, Design object, Designer and Environment. Modified from Torrens (2018, p. 67)

products, even without including design management. The standard for Inclusive design, British Standard BS7000-6: 2005 (BSI, 2005), provides details associated with design management.

Fig. 5.6 provides a better understanding of the point of application within a conventional new product development model. The Universal Method of Design provides a simplified design and development process (Hannington and Martin, 2012). The "care" approach is applied primarily during Phase 1-3 and Stage 1-5 of conventional new product development processes. The box at the bottom left corner of Fig. 5.7 specifies methods and procedures associated with Universal Design, which is based on the authors' many years of accumulated knowledge in the field. These methods and procedures help designers to be more sensitive to users' needs and become more "caring" in the research and design process.

A Universal Design approach has a number of defining attributes:

a. it is participatory and inclusive, involving all actors in the process;

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b. it is holistic in scope that includes some elements of systems analysis and engineering;
c. it is applied within a social model of assistive technology product and service design;
d. it is multi-sensory in the communication of all aspects being described.
e. it offers multiple outcomes with consequences beyond the immediate human scale interface.

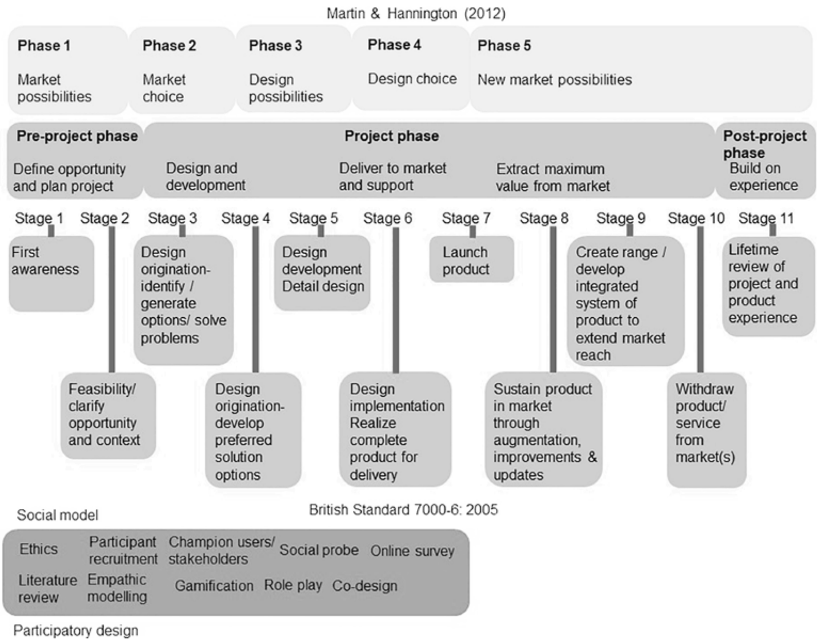

Fig. 5.7 - Contexts and specifics of Universal Design. Modified from Torrens (2018, p. 70)

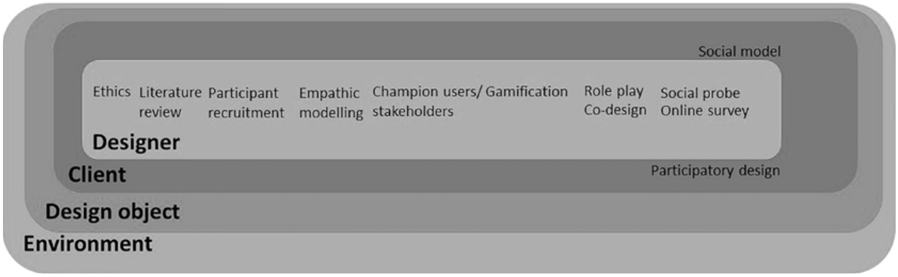

Fig. 5.8 - The "care" toolkit for designers

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Fig. 5.8 provides more detail of the research and design methods and tools that make up the care approach in the product design context. An aspect that encompasses the care approach is ethics. Eliciting requirements from clients/end users of the design outcome; and, the additional consideration of what the design outcome may do to the wider physical and social environment demands a clear ethical standpoint. Two other key aspects that are critical to the effectiveness of the approach are participant recruitment, etiquette and interpersonal skills. The following case study describes these aspects.

5.4 "VI Boccia Grid" Case Study: Developing a Game for Visually Impaired People

In 2010, funding was provided by Sport England to develop inclusive sports products for Visually Impaired (VI) people. One of the products developed was the VI Boccia grid. The inventor of VI Boccia, Mark Beeby, a sports coach in the UK, had been developing a training programme to enable people who had visual impairment or were blind to be able to play the inclusive game Boccia. The Paralympic sport Boccia is a form of French "boules" played with sand-filled leather balls rather than on an area of sand. Mr Beeby had trained a small group of people who were visually impaired to effectively throw the balls to a line and length. He had developed coaching drills to overcome their sight loss and enable the VI players to play effectively against sighted opponents. However, there was an issue with playing the game more strategically. VI players needed some way of perceiving the relative positions of their balls and those of the opponents to the "jack" ball. Mr Beeby had devised two prototypes prior to the

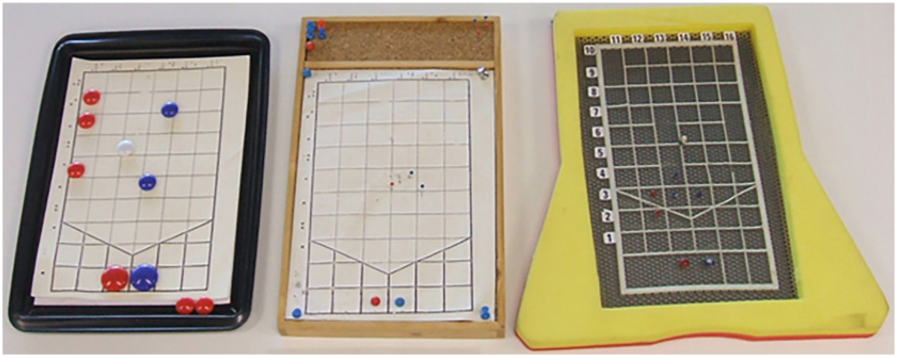

Fig. 5.9 - VI Boccia grid early prototypes alongside the initial test-bed prototype 2010 (on the right)

project starting: a metal baking tray using magnets and a "pin-board" of a cork base covered by an embossed paper representation of the Boccia court using graph pins to represent the balls (Fig. 5.9). He approached the Loughborough Design School to develop a more effective grid.

Many methods and tools from the toolkit (Fig. 5.8) were applied in the design process, e.g. literature review, Co-Design, champion users, ethics, participant recruitment, and modelling.

Literature Review. An initial literature review was done to define the scope and boundaries of the product design:

- primary medical conditions that result in visual impairment or blindness and associated conditions that result in poor balance, tremor, learning difficulties or other compounding impairments;
- number and age of adults and children affected in the UK and Internationally, this provided with a potential market size in different socioeconomics categories;
- associated safety standards, industry guidelines and competition rules associated with the VI inclusive sports product and game;
- associated medical treatments or rehabilitation therapies that may affect the perception or use of a new product;
- existing similar products or those already used in Boccia, such as Boccia balls, measuring jigs and ramps, that may affect how the grid is used;
- where the game would be played;
- the cost of other equivalent or associated equipment or products.

The results of the literature review indicated the medical conditions in younger people were often associated with congenital conditions, with VI or sight loss from birth. In older sections of the population, VI or blindness were due to lens degradation from Ultra Violet sunlight exposure, injury, or associated conditions such as diabetes. There were around 30 Boccia clubs in the UK at that time, with approximately 300-600 players. Boccia was extensively played in special education schools. In the UK there were around 1,200 schools at that time. A realistic estimate was that there was a market in the UK for around 120 units. There were no similar products on the market against which to price the product; only the two prototypes existed. However, a set of Boccia England endorsed balls cost around £120. General British and European standards for product safety were the closest to the performance criteria for the product.

Conventions for haptic reading formats that were likely to be known to the players were Makaton (2019) and Braille (RNIB, 2019). The level of fidelity of sensory perception relating to braille reading was used as a basis for the scale and proportion of the markers representing the balls on the grid. This was a height of 1-2mm and a smallest spacing between asperities being 0.5mm. The VI classifications for Paralympic sports were used to further characterise participants (Paralympic movement, 2019).

Co-Design: a team of three special education sports coaches, one academic industrial designer and four undergraduate industrial designers worked on the initial project to produce a batch of five grids, with a master's graduate level student involved in the subsequent development for manufacture of a batch of 100 units. The subsequent development was supported through internal University enterprise funding.

Champion Users: there were two champion users who provided the majority of feedback on the first prototypes and those subsequently produced by the design team.

Ethics: before communication started between stakeholders and design team, ethical approval for the project was obtained. Using an ethical approach to research and design activities ensures the safety and well-being of the people taking part in the activity, and the people running the activity.

The design and research validation activities were planned within the constraints of ethical guidelines. As a larger organisation who takes part in research involving human participants the University had a designated group or committee to review procedures (the recipe) used within any activities involving human participants.

This group considers a number of issues within a proposed project or study:

- aim and objectives of the human-based activity, the research questions answered (is the work needed?);
- awareness of vulnerabilities of participant and activity operator/investigator (do no harm physically or emotionally);
- working with young people and children (presenting information they can understand and involving guardians or advocates);
- information for the participant regards the purpose of the activity;
- a consent form to enable the participant to positively confirm involvement;
- making payments to participants (including, travel and expenses, inconvenience);
- data protection (how the information will be stored, used and for how long);

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- rigour, respect and responsibility of the operators/investigators (all potential issues or circumstances considered, including cross-infection, preparation between participants and avoiding bias);
- invasive/non-invasive (taking blood samples, or just looking at information);
- appropriate health and safety measures, including aftercare (sub-maximal exercise, food, water, hospitality, showers, cleaning, and appropriately qualified medical support).

There are a number of detailed references that provide guidance on the ways in which both participant and research operators can be safe guarded and provide templates for an ethical approach to mixed research methods (Cohen, Mannion and Morrison, 2007, pp. 51-77; Wilson and Corlett, 1995, p. 87). In this case, there were a series of challenges to address. These included:

- digital ethics consent forms to enable visually impaired/blind participants to read the planned activities. The interaction with prototype products was explained in the participant information sheet along with an explanation of why the study was being done and what would be done with information collected from them.
- Etiquette of participant interviews; the designers verbally introduced themselves when they entered a room with participants; not touching, holding or physically moving the participant without first asking and gaining permission. Enhanced verbal descriptions and explanations that include orientation and distance, which would often be given through gestures, such as pointing.
- During interviews, researchers sat at 90 degrees to the participants and below eyeline to ensure a non-threatening or assertive posture.

Participant Recruitment: for vulnerable groups, such as children or adults with learning difficulties, the participant information sheet (PIS) and recruitment flyer (which would be a summarised version of the PIS), would include images, possibly a scenario of the protocol being applied, and emoji symbols, such as happy or unhappy to help the participant indicate their preferences. An additional PIS would be made available for the Guardians or Advocates of the participants.

Online special interest groups and internet marketing have helped in accessing the previously difficult groups and markets. If, for example, Facebook is being used to recruit participants the participant information sheet and ethics consent form should be fixed on the front page, to enable those who are considering taking part to make an informed choice.

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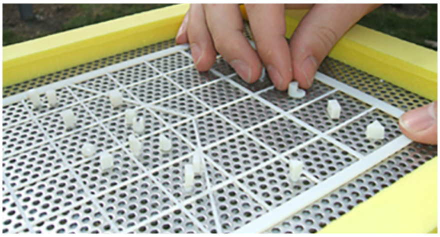

Fig. 5.10 - Prototype marker pins and grid

Fig. 5.11 - VI Boccia grid designs

Recruitment of participants who are willing and able to engage for the whole project is time consuming and challenging. Sports product research and assistive technology (AT) development are good examples of "niche" markets (Torrens and Black, 2011). The champion users provided the basis for initial cycles of development, which reduced the time in recruitment of individuals who would be actively involved throughout the project.

Recruitment for the second phase consensus seeking was made straightforward through working with a Sports College and using the opportunity of a Regional Boccia tournament locally to recruit participants. As there were no images or video taken, recruitment was done when players for the Boccia tournament arrived. Parents, Guardians and advocates along with players were given the participant information sheet document and asked to sign a consent form. A tip here is that lead researchers must make the initial links with Charities or support groups who are the likely beneficiaries of the design outcome before trying to recruit directly from the population. This sequence of recruitment will also engage a wider group of stakeholders in the form of specialists (in this case healthcare and Visually Impaired/Blind occupational and teaching) within each charity. If it is solely a commercial project, some financial payment would be expected for the participants. Since this project was a social impact project, participants were willing to take part without reward or compensation for the time and inconvenience.

Modelling: the feedback from Champion users was used to check the scale and proportion of the marker pins, shown in Fig. 5.10, and the choice of shapes to differentiate the competitors' pins from those of the player and the jack ball. The Figure also shows the background grid profile was defined through iterative cycles of participant Co-Design. Although a 1mm thick stock stainless steel perforated sheet was used for the test bed, the scale of the pins and pitch distance between the centres of the largest markers was used to specify the pitch of the pin holes in a subsequent compression-moulded rubber grid base.

Different widths and edging shapes were used in early development prototypes, but it was found that players preferred a more compact grid that could easily be held in one hand whilst seated. The scale of the grid in relation to the real court was 50:1 (Fig. 5.10).

The final production version was produced using a vacuum formed outer casing, with a compression moulded grid based. The pins were injection moulded. The outer casing had flat sections to take sponsors' advertising. A carry bag was added to display sponsors' logos (Fig. 5.11).

Nearly ten years on from development, VI Boccia game and grid is played Internationally. The VI Boccia grid is now commercially sold via Handi life Sport (Handi Life Sport, 2019), who have indicated that 162 grids have been sold into 13 countries. Taiwan have the largest number, 26, alongside the US. In Taiwan they have now set up a special VI Boccia League.

5.5 Discussion and Conclusions

The participatory approach applied in developing the VI Boccia grid is a "bottom-up" process. The reason for this choice is to minimise risk. Risk referrers to the return on the investment of money, time and resources to the project through a successful (profitable) design outcome. The "profit" may be financial, social or environmental. The goal of this process is to minimise the number of iterative cycles of development. Less cycles of development, less time taken and less cost to achieve a feasible and viable design outcome.

When applying a Co-Design method, the authors have found that physical objects, existing products and low-fidelity models, combined with role play, evoke a much richer response (Torrens, 2017, p. 275). In both case studies, the physical game prototypes worked really well.

The "care" model and the "My Home" game developed for the interior context may well work for a product design context – this will need validation. The "care" model is more conceptual while the "relationship" model is more practical. By linking the "relationship" model with existing models of product design, the authors hoped that the readers would pay more attention to the etiquettes and practical details which are essential for an Inclusive Design process, a process emphasising care.

In summary, in order to understand "care" in the design context, and acknowledge the wider social, cultural and physical environment for Universal Design, the authors have developed two models: a "care" model for interior designers (Fig. 5.1), and a "relationships" model adapted for accessible product design (Fig. 5.6).

The "care" model suggests that to care for the micro-environment, designers have to transform clients and things from "care receivers" to "care givers", passing "care" from design activities to the external environment. In the process of this transformation, designers must first improve their abilities of care. The "My home" case study has offered a practical approach (i.e. a game to be played in the early stage of Interior Design) to developing designers' abilities of care. The evaluation of the game suggests it has potential to make designers be more aware of care.

The "VI Boccia grid" case study has highlighted some aspects of applying the "care" toolkit in real product development, for example, ethics in its broadest context, and the challenges faced when recruiting participants. In this case study, "care" has been implemented using methods and tools for Inclusive Design.

The models and the case studies have provided frameworks and methods for design educators, students, design researchers and practitioners, to help them understand "care" and implement care, in both Interior Design and product design contexts.

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6. Design and Prototyping for Disability. WAVE Case Study

by Lorenzo Berti, Piergiorgio Callegher, Cecilia Garuti, Vittoria Roccatelli, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the methodology applied for the development of Wave, an open source assistive device for blind people.

The project was developed during the "Intelligent Products" Design Studio, of the Product Design Master Course at the Iuav University of Venice.

WaVe is an open source assistive device for blind people that is designed to be attached to the standard white cane to help the users while memorizing new routes in urban context, granting them more autonomy. We cooperated with a blind user, that helped us to understand the main problems in his experience of urban orientation, as example the necessity of tutoring assistance for the study of a new route, requiring multiple walks before proper memorization. Our purpose was to give the user more autonomy, reducing the number of meeting with a tutor: WaVe allows the user to record new routes through reference points, giving him the possibility to retrace them in autonomy. To reach this aim, we decided to use RFID technology, using passive tags as reference points, and the cane as antenna. The product development process started thanks to a series of interviews that we submitted to the user, which allowed us to understand that the topic of autonomous orientation is really felt by the blind, who often have to compromise. Analyzing the results of the interviews we have chosen to work on the white cane, a support that is always present in the life of the blind and that leaves many possibilities for intervention.

The design process has always developed using tools open source, in order to guarantee an easy reproducibility of the final product. The user contribution was fundamental during the design phases, useful to understand the real needs and making changes during the work. Wave strongly improves the user's autonomy through the reduction of the need of memorizing information.

Keywords: *Design Open-Source, User Centered Design, Learning Experience, Blind Orientation, RFID.*

6.1 Introduction

A blind user can find lot of difficulties during outdoor orientation, caused by many factors as a though environment, other people distraction or necessity to find non-visible references, and all of this requires a great amount of concentration.

WaVe is an assistive technology for blind people, that helps them to reach their autonomy in daily habits. The device has been designed to allow the user an easier memorization of his usual or new routes, reducing the needs of a tutor for training walks: nowadays, the memorization of a route can happen in different way, but all of these happen with the help of a tutor for many times. With WaVe, we used technology to make this process easier, both for the user and the tutor, turning the classic white cane into an antenna, capable to store a new route in his journey.

6.2 Methodology

During the project we were assisted by a man affected by late blindness, that offered as volunteer to help us to identify the problem and test our prototypes for the product development.

The first phase was about the identification of the problem and the focus on specific connected issues, then the research addressed the spatial reeducation of blind persons as the most important phase to get back their autonomy.

The research was first centered on how people affected from late blindness learn to come back to their regular life. Most of the work is made from associations, that provide lessons and tutors for the blind people but, in a second moment, technology can have a very important part in making easy the actions that usually would require a tutor.

At this point our volunteer was directly involved in three meetings: the first was made to identify the problem itself, and came out how outdoor orientation could be a real issue; the second, to understand his orientation technique, made up of:

1. first walk with a tutor;
2. subdivision of the route in segments;
3. assign to every segment an amount of steps;
4. reconstruction of the route on paper, in order to store it;
5. repeating the route with tutor until found confidence (usually 5-6 times).

And the third, in which the user showed us how the technique was applied in an outside walk. The process works very well, but asks to the user a great amount of concentration during his route: he must count every step walking, and every little error can be very relevant at the end of the segment.

Following the identification of the problem, we conducted a desk research on the existing products available for blinds and understand which technology can provide a correct localization.

Most of the found products did not contemplate GPS localization as solution, mostly for the fact that GPS has an accuracy up to 3 meters, too much to guarantee a safety trip to a blind user, specially in a city as Venice, our case study, in which the small and close roads can cause many problems.

Our design took the right inspiration specially looking indoor orienteering projects, such as museums or airports. We understood that the user did not need to be tracked for all the route, but he simply had to identify some hotspots, such as in the turns or in danger points.

We have identified RFID technology as the best technological solution: it consists of an antenna capable to read sensors. Since sensors have an unique identification number and don't need alimentation, we have decided to give the user the possibility to place them through all the city, and to transform the standard white cane into the antenna to read them.

After developed the design, and after had the confirm by our user, we started to build the prototype.

The purpose to have an open source product brought us to use open source technology and easily available materials, such as arduino for the electronic part or 3D printing for the shell construction.

Once had the prototype the project ended with a first field research, in which we found some errors in usability of the product that were corrected and tested in a second field research.

6.3 Results

The project was developed during the “Intelligent Products” Design Studio, of the Product Design Master Course at the Iuav University of Venice. WaVe is an open source assistive device for blind people that is designed to be attached to the standard white cane to help the users while memorizing new routes in urban context, granting them more autonomy. We cooperated with a blind user, that helped us to understand the main problems in his experience of urban orientation, as example the necessity of tutoring assistance for the study of a new route, requiring multiple walks before proper memorization. Our purpose was to give the user more autonomy, reducing the number of meeting with a tutor: WaVe allows the user to record new routes through reference points, giving him the possibility to retrace them in autonomy.

The aim of the project is to give directional instructions to the blind or visually impaired user, leading him step by step along his usual routes through the transmission of informations related to a series of reference points: in fact some of the rehabilitative techniques, aimed at teaching autonomous orientation, are based on the teaching of how to acquire various points of reference, points that the blind person can use in order to recognize a piece of road while walking along it.

The intention is to make possible a “tracking” of a series of routes by the user himself, who will use a device that can be applied on the white stick and a series of RFID tags which he will position at each crossroad of interest along his usual routes.

Every RFID tag is characterized by a code and once the RFID systems have been positioned the user will be able to store on his database all his “paths”, which interpolate the tags placed around the city: these memorized routes can then be selected from an online application, to guide the blind person around the city through tactile and auditory feedback.

The user can also add personal notes that will be read by the device in the proximity of a tag, in order to provide more information about the area in which it is located: in this way the user can personalize the information that WaVe provides him, entering information of personal interest or related to any elements of danger present on the route.

Once the tags have been positioned by individual users, these can be used by any other WaVe’s user, with the aim of creating a sort of community around the product itself: after identifying the tag belonging to someone else, the blind person will be able to register it on his personal database and use it in order to create his own routes.

Prototype. WaVe is a device that can be applied to any standard folding white stick: in this way the project is able to better respect the typical logic of an open source project.

The external shell is 3D printed and consists in two main parts: the tip, in which the antenna and the RFID module for reading the tags are positioned, and the handle, in which the battery and the rest of the electronics parts are positioned. The external shell also includes two buttons, which allow the user to interact with the device.

WaVe is powered by a rechargeable battery, so that it is easy for the user to control his charge level. All internal components are controlled by an Arduino

Wifi, which guarantees its working and the connection to the online database and the site.

The bill of materials includes:

- Arduino Wifi;
- a standard white folding stick;
- RFID Module;
- RFID Antenna;
- 1 DF Player for audio feedback;
- 1 vibration motor for vibration feedback;
- 2 buttons, for the registration of the tags, the audio notes and the reverse routes;
- 1 power button;
- a rechargeable lithium battery;
- 3D printed components;
- various electronic components.

During the development of the prototype we found it difficult to find the most suitable RFID technology for WaVe: in fact for the final product the technology to be used is UHF (Ultra High Frequency), which works between 860 and 960 MHz and is characterized by a range of action between 40 cm and 1 meter. However, this is a technology that is difficult to find in a short time: for this reason we made the prototype with a 125 kHz RFID antenna, easier to find but with a range of only 15 cm: in this way we were able to prototype WaVe and test its functionality and limits with the user, despite the technology used was not the most appropriate. This process allowed us to understand what changes to make to the project in order to make it easier and more comfortable for the user.

Shared materials/instructions. WaVe is an open source project, and for this reason it is important that it can be easily reproduced by anyone.

The entire project was developed with the aim of being shared on Posta: an open source platform born from the collaboration between Italy and Argentina with the aim of making assistive technologies accessible to anyone in any part of the world. The open source logic is in fact based on the sharing of online projects, allowing them to be easily downloaded for the purpose of being used.

The materials shared on Posta, so that WaVe can be easily reproduced, are:

- 3D model of the outer shell;
- electric Scheme;

- bills of materials;
- code for Arduino;
- instructions.

6.4 Conclusions

The main aim of WaVe is to guarantee greater autonomy for the blind in the urban context.

The project is able to lighten the amount of informations that the user usually has to memorize in order to be able to orient himself, avoiding to distract him excessively thanks to the use of non-invasive feedback, preventing any dangerous situations.

WaVe is easily reproducible by the user himself considering that it is an open source project, and allows the blind person to involve the tutor fewer times for the memorization of a route.

At the moment we have prototyped the stick (the tip and the handle) and created the online database, with a simulation of the site.

With the development of the project and the direct relationship with the user we have had the opportunity to understand how it is actually important for a visually impaired to acquire greater autonomy, especially in the city context.

The main problem we have encountered is about the positioning of the tags around the city, for which a permit would be required from the city municipality itself: however, thanks to the generation of a community around the WaVe project, it would be easier to obtain consent and diffusion.

Furthermore, during the research phase we discovered that there are numerous types of RFID tags, characterized by different fixing methods: in this way it will be possible to select the most appropriate type of tag for each city context.

We can then assert that, despite these possible limits concerning the positioning of the tags, it is possible to find compromises so that the positioning is accepted by the city municipality.

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7. Design and Prototyping for Disability. DÌA Case Study

by Francesca Ambrogio, Joelle Cifelli, Allegra Corrente Fornoni, Francesca Pian, Matteo Rossi, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the approach applied for the creation of Dìa, an open source blood glucose meter controlled through an Arduino board. The project was developed during the "Intelligent Products" Design Studio of the Product Design Master Course at Iuav University of Venice.

At the beginning of the design process a User Research has been conducted. It consisted by diabetes-affected people interviews and online questionnaires. This phase was fundamental to achieve our objective: a user-oriented product. Starting from the existing Open Source project, the "Open Source Arduino Blood Glucose Meter Shield" that we found on hackaday.io, we have implemented it by integrating a code for the data transmission with a Node MCU, the design of the shell, the study of a new mechanism for the lancing and the creation of a Web App accessible both from the user and from the doctor.

"Dìa" is a product that has four main features: lancing, glucometer, sending data to a WebApp for smartphone and the creation of measurements history performed by the user. Dìa is an integrated product that allows the diabetic patient to have always the opportunity to sting the finger and detect the blood sugar: everything is inside one product connected to a WiFi and a WebApp. The study of the product and service is one of the foundations of our project because we are convinced that, despite the new sensor developed for diabetic person, the blood glucose measurement is the only measurement that the patient can really trust. An imperative is therefore to be able to maintain an historical measurement and, at the same time, have a dialogue at any time with the doctor, who has the possibility to check the glycemic trend of the patient. At the end of our study we've created a functional prototype, exhibited during the "Design Open Lab" at the Iuav University of Venice.

Keywords: *Design Open Source, User Centered Design, Learning Experience, Diabetic, Integrated device.*

7.1 Introduction

Dìa is a project of assistive technology developed according to the design method proposed by "Intelligent Products" Design Studio, of the Product Design Master Course at the Iuav University of Venice (Romero, Ferrari, Toso, 2018). After a desk research conducted on the devices that diabetic patients use daily to monitor their glucose level, we have focused our attention on the guidelines provided by the Italian healthcare system and on the devices disposable on the market. In this way we have analyzed the technology state of the art and the modality of use of the common devices. We have consequently decided to improve the design in compliance to an open-source project (Open Source Arduino Blood Glucose Meter Shield", hackaday.io). Our project is focused on the method, and so the gestures and habits of the patient that use the glucometer. The material chosen to make the product is the PLA.

User and Platform Identification. The project has been designed from an OpenSource perspective. We assumed as target users between 16 and 50 years old. We've set this target because the product requires basic knowledge of 3D printing and the dynamics of OpenSource projects in order to have access to the platforms and the technologies for its production.

For the distribution of "Día", the POSTA project (www.postaproject.org) has been chosen as reference platform from which it will be possible to see and download the project, build it, use it and implement it.

Identification of Existing Problems. Through these tools (questionnaires, users research and interviews) we have identified the glucometers' problems that can be classified in three categories:

- Usability;
- Functionality;
- Connection.

In particular, the critical issues regarding the "usability" are:

- glucose meters without the possibility of having a history of the measurements: The glucose meters currently available in the market, do not allow to "record" the daily measurements made by the user and consequently to create a history of the measurements themselves;
- glucose meters not very "usable" and ergonomic: currently glucose meters are uncomfortable; they involve a complex gesture of the users;
- absence of integrated glucose meters with lancing device: at the moment there are no devices that combine the two functions.

The "functionality" of the glucose meters is often reduced, missing, superficial, but despite these problems they are used as fundamental tools because they are essential for a diabetic patients. They use various technologies for measuring blood sugar such as extracutaneous or subcutaneous sensors.

As far as the chapter on connectivity is concerned, the discussion is divided into different subcategories because we are not only talking about a connection between the glucose meter and an application for smartphones, but also about telemedicine. More specifically:

- impossible to check the glycemic value due to an application on a smartphone (when the subject is not at home and makes a glycemic measurement with the current instruments);
- daily/weekly/monthly glycemic trend graph. So the absence of the possibility of an history;
- impossibility of telemedicine and the constant relationship with the treating doctor.

7.2 Metodology

The methodology proposed by the course required a direct and close relationship between designer and final user, in order to create a sort of collaboration to achieve a common goal. The steps followed for the realization of the project are:

- identification of the user;
- questionnaires;
- interviews;
- research on the state of art;
- project brief;
- concept definition;
- project development;
- final prototyping.

7.2.1 Identification of the User

The project has been designed from an OpenSource approach; it is assumed that the user is a diabetic patient aged between 16 and 50 years old. We have defined this target group on the basis of the questionnaires that we have diffused on internet, specifically we have used the Facebook platform. The result of the questionnaires revealed a strong presence of women with type 1 of diabetes in an age group ranging from 21 to 37 years old. The step after the questionnaires were individual interviews. As we defined the target audience, we identified two users who were in line with the results obtained.

7.2.2 Questionnaires

To investigate and have a better idea of the User Experience, we have drafted a questionnaire to submit through social networks; that choice has been made to enlarge our sample. The questionnaire was created with "Google Modules" and was published on Facebook in restricted groups of diabetic patients and on our personal pages.

The choice to publish the questionnaire on Facebook was motivated by the fact that we wanted our target audience to be relatively young people and open to new types of care/glycemic measurements.

The number of filled questionnaires was 95: 91 people have type 1 diabetes mellitus. We also noted that the average age of the people who answered was about 26 years with a majority of women.

An important fact obtained from the processing of the questionnaire data was that 89 diabetic patients use sensors to control blood sugar but they all said that they never go out without their traditional glucose meter. Based on the data collected, we decided to implement a new glucose meter: it's an essential device for diabetic patients even though the most common products on the market are sensors. Companies tend to focus their attention on new sensors that use innovative methods for measuring blood sugar, but the glucosemeter is the only instrument that allowed to measure the real glicemic level.

7.2.3 Interviews

The people chose as sample for the investigation are Camilla 25 years old and Costanza 24 years old, both affected from type 1 diabetes.

The interviews allowed us to undertake a qualitative and personal analysis of the issues because they were conducted at two different times during the project. The first interview, that take place on December 4, 2018 with Camilla, was placed in the first period when were not considered yet the traditional glucose meters but only extracutaneous sensors for the detection of blood sugar. An important problem for Camilla is not having a regular life as regards meal times because doesn't feel comfortable in using her glucometer. She has repeatedly claimed that although she is currently using the Dexcom G4 sensor, she never leaves the house without glucometer.

The second interview was conducted with Costanza. In that case it was possible to highlight issues and go deep considering the phase of the project, more mature. This second interview was conducted on January 9, 2019, when the clear objective to achieve was to create a glucosemeter.

The design change was determined by the comprehension of the impossibility of action, for our working group, in the field of sensors for glycemic control because it involves the use of technologies with very small size (almost exclusively owned by pharmaceutical manufacturers). Due to this costraint and many doubts arising from the words of Camilla, we decided to discover what was actually the importance of traditional glucose meters for the diabetics. We interviewed another person who uses the FreeStyle Libre sensor for blood glucose control and the pump for insulin intake, a very different situation from Camilla.

It was possible to identify the differences and similarities between the two people and to define our brief.

The problems encountered by Costanza are located in the user interfaces and in the shapes of the devices she currently uses; she also highlighted the importance of the glucose meter despite its inconvenience from different points of view. The questionnaire was our method of research and quantitative analysis. A questionnaire was drawn up, based on the research conducted, offering the user a range of possible answers with also the space for comments in case the ones proposed by us did not meet the needs.

7.2.4 Research on the State of Art

The state of the art that we have carried out is based on desk research of what is currently on the market regarding lancing devices and glucometers, in addition the study of existing Open Source projects. We also bought some lancing devices to be able to disassemble them and understand more in detail their internal structure to redesign it.

7.2.5 Project Brief

After the research phase, we have defined our project brief, consisting in a glucose meter with compact lancing device and dialogue integration with smartphone application for data communication.

Dìa was born from the need to have an integrated product so that the diabetic patient can limit the load of instrumentation to carry always with him. So, it's a product capable of lancing and measuring blood sugar. Dìa offers a very simplified exchange of data and information between the diabetic patient and the treating physician.The doctor can, at any time and from any device, have access to patient's page to see the content.

7.2.6 Concept Definition

The starting point is the OpenSource project "Open Source Arduino Blood Glucose Meter Shield" by M. Bindhammer.

The main points of this project have been:

- the Arduino firmware;
- the hardware component that governs it and therefore allows the reading of the level of glucose in the blood. Shield (printed circuit board) that, thanks to the use of connectors and TPS, allows the reading of blood.

Our intervention is divided into several aspects:

- elimination of the use of the LCD screen;
- new writing of Arduino's firmware by reformulating the logic of writing and operation;
- further implementation of the code given by the use of mathematical functions to reset all the operation of the printed circuit board for a device with capacity to work at 3.3 volts and not at 5 volts as in the firmware of the reference project;
- creation of an integrated and easily replicable product: lancing, blood glucose detection, blood glucose level LED feedback, product;
- study of a new lancing mechanism;
- product study;
- design and creation of a WebApp, which can be consulted from the patient's mobile device and from fixed workstations. Also from the doctor's PC, whichis in constant dialogue with the device and with the history of the measurements performed.

7.2.7 Project Development

The project development consists in the elaboration of the feedback given by the user on the problems found and the definition of formal and functional details, such as materials, electronics components, dimensions, position of the elements that allow user-product interaction.

7.2.8 Final Prototyping

The last step consists in the final prototyping of the project. The goal is to obtain a working prototype as similar as possible to the product previously designed and developed, both in term of form and functionality. The result was an integrated product that had inside the main and essential functions for the use of the glucometer. We've completely studied the lancing device part and its functioning in a way that is totally reproducible and reconstructible in 3D. The device can be reproduced by those who have basic knowledge of 3D printing and technological skills.

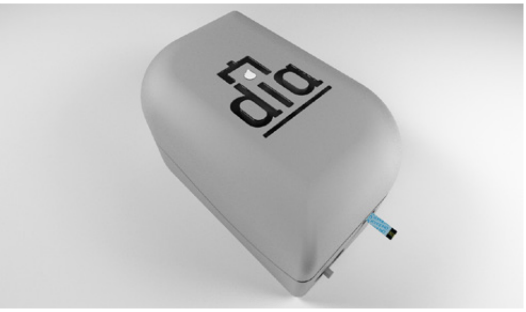

Fig. 7.1 - Render of final product and the design of the logo

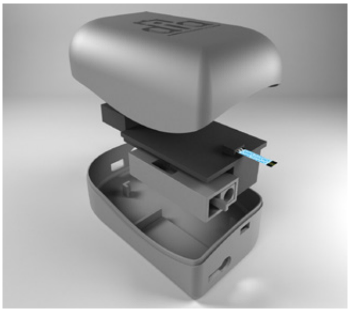

Fig. 7.2 - Render components and how they were places inside

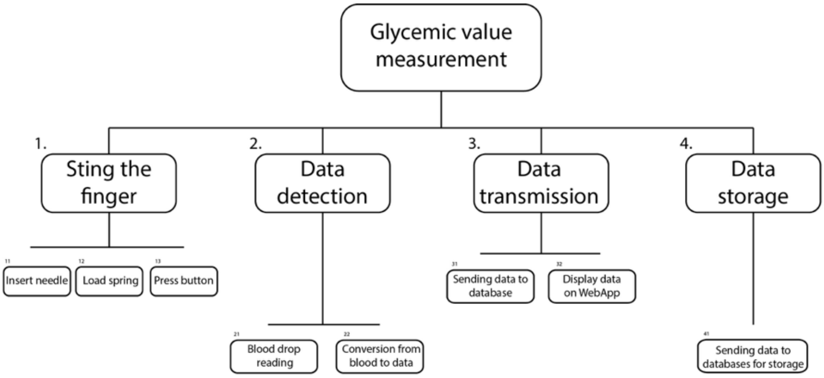

Fig. 7.3 - Task Analysis of the interaction between product and WebApp

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7.3 Results

The described design methodology was fundamental for the prototyping of Dìa, an integrated product that allows the diabetic patient to always have the opportunity to sting the finger and detect the blood sugar: everything is inside one product connected to a WiFi and a WebApp.

7.3.1 The Product

The physical realization of the product required the improvement of the following skills:

1. ergonomic study of the size and position of the elements of interaction with the user (buttons, invitations to use), (Tosi, Rinaldi, 2015);
2. ability to develop the design of the object with various study models, keeping in mind the dimensions of the electronic components;
3. 3d modeling and preparation for 3d printing;

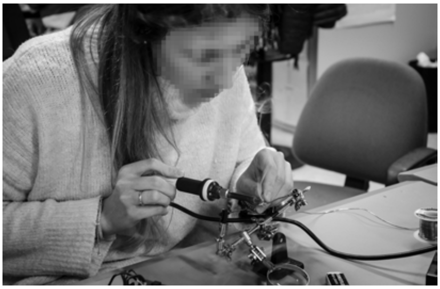

Fig. 7.4 - In this photo the moment of the soldering of the electronic components

Fig. 7.5 - The coding work that has been done for the Arduino and Shield code

Fig. 7.6 - External shell of the product in 3D

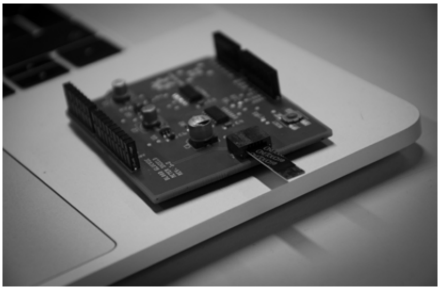

Fig. 7.7 - Internal product shield

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4. fundamentals of electronics: learn and manage the main electronic components (creation of electrical diagrams and electronic welding);
5. programming basics: chip firmware writing based on the functionality required for the prototype (Arduino and Open Source libraries);
6. assembly of components.

The result was the realization of a 3d model of the components, printed in PLA with 3d printer, that made Dìa structure: body (which contains all the electronic components) and lancing. Consequently these parts have been assembled together with the electronic parts: on/off switch, 4 led, printed shield, chip (NodeMCU), 9v battery.

7.3.2 The Web-App

MySQL Database. Free software, defined as an open-source Relational database management system (RDBMS) available for free that uses Structured Query Language (SQL, the most popular language for adding, accessing and managing content in a database), consisting of a command line client and a server. It's known for its fast processing, proven reliability, ease of use and flexibility. MySQL is an essential part of almost all open-source PHP applications.

The database is structured according to a subdivision into tables:

1. Table users, in which are inserted Username, Password, Date of birth, Weight and sex, relating to each user previously registered on the online platform;
2. Values table, in which are inserted Username, date, time, glycemic value and comments/notes.

When the user takes the blood glucose measurement through the device, the device is sent to the database, registering in the Values section.

The Arduino only communicates the blood glucose value to the database; the date and time are managed by the MySQL server, which picks them up based on when the value is received.

Software used:

- HyperText Markup Language – HTML – is a markup language, created for the formatting and layout of hyperlinked documents available in web 1.0;
- JavaScript is an object and event-oriented scripting language, commonly used in client-side Web programming for creating dynamic and interactive effects on websites and web applications;

- CSS (Cascading Style Sheets) is a language used to define the formatting of HTML, XHTML and XML documents such as websites and related web pages;
- Adobe XD makes it easier to switch between graphic and programming code settings. Final export to Java and HTML.

7.3.3 Mode of Use

The user turns on the button on the device. When the device is on, the white LED blinking and it does not stop until it finds a Wi-Fi connection. When the Wi-Fi connection has been found, the user inserts the One Touch Ultra strip inside the product, stings his finger and places the drop of blood on the strip, where it is absorbed. The device analyzes the drop and provides a numerical data as outcome of the process, then the data is transmitted to the Node MCU which converts it and sends it to the online database. During the time that the data is stored in the database and arrives at the display on the app, the device responds with a bright red-yellow-green feedback based on the glycemic value. Red (50-79, 231-280), Green (80-180), Yellow (181, 230). After that, the user can insert his/her credentials on the app and have a real time display of the glycemic data. From the app it's possible to see the trend of measurements made during the day or month. Next to each measurement the user can make notes and comments that are also functional for the doctor, who can have information on the profile.

7.4 Conclusions

The dialogue and integration of Open Source projects with other commercial products was one of the great challenges behind the Dìa project. The language of firmware had to be integrated with the language of "closed" products existing on the market. This is one of the problems that Dìa solves by widening its gaze and giving not only a functional opportunity, but also a coherent and expendable formal solution. Indeed the products on the market are protected by copyright and their firmware is not design to be customized, so working in a open-source perspective allowed the customization of the devices to and for end users.

Secondly, the use of the Webapp compared to a traditional application allows the user and the treating physician to have access at any time from any device in the world (PC, smartphone, tablet, etc.).

The enrichment and contribution provided by Dìa is: an ex-novo study of the shape of the product, components and lancing mechanism. From the construction point of view it is easy to assemble and build even for those who are not practical in the field. The increase of the software is surely important because the Arduino programming code, from which the project started, has been modified in order to develop a code that is able to dialogue directly with the WebApp and therefore does not force the user to use the PC whenever he needs to measure blood sugar. The analysis of the processing and storage of sensitive data was not taken into account at this stage of the project and can be considered as one of the possibilities for its implementation.

Acknowledgments

Dìa is a product designed by Francesca Ambrogio, Joelle Cifelli, Allegra Corrente Fornoni, Francesca Pian, Matteo Rossi. Thanks to the collaboration of the users, Camilla and Costanza and to Giovanni Borga for the technical support.

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8. Design and Prototyping for Disability. E2E (EAR-TO-EYE) Case Study

by Alice Forestan, Camilla Antea Erba, Denny Roncolato, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the methodology applied for the development of “E2E (Ear-to-eye)”, a lighting assistive open-source product for deaf people. The project was developed during the “Intelligent Products” Design Studio, of the Product Design Master Course at the Iuav University of Venice (Romero, Ferrari and Toso, 2018).

The hypoacusis is a disease caused by damages in the internal ear that reduces the hearing ability. The hearing aid and the cochlear implant are the main solutions to the hypoacusis (Nidcd, 2019), although they are removed or switched off in some specific situations which take place at home (such as studying, sleeping and relaxing) causing an uncomfortable feeling of total isolation.

After a desk research, we interviewed four deaf people and we identify as critical three situations that take place at home when the hearing aid is removed:

- someone rings the bell at the front door;
- the alarm clock sounds in the morning;
- someone from a different room is calling.

The purpose of the project is to involve the deaf person into events happening in the domestic environment when she/he might not wear the hearing aid in order to reduce the sense of uncertainty and isolation. To address this issue, we have designed E2E, a system of two or more devices positioned in different rooms and connected each other through radio frequencies. The devices are provided with three different LED lights: two of them activate when the microphone recognizes the sound of a bell/alarm and the acoustic signal is converted into a light feedback; the third one is used to communicate with a person in a different room. The interaction takes place through two different buttons, one to send a call signal and the other one to send an answering signal.

Keywords: *Design Open Source, User Centered Design, Learning Experience, Hypoacusis, Visual Feedback.*

8.1 Introduction

Hypoacusis is a disease that involves the reduction of hearing capacity due to damaged parts of the ear designated to the mechanical transmission of sound waves or the degeneration of one or more components related to the inner ear. Different typologies of damages may cause a wide range of shades in hearing loss (Mayoclinic, 2018) and they are named according to the levels (mild, medium, severe hearing loss).

People suffering from hearing loss have often difficulties to communicate: they tend to exclude themselves from social relationships and to group together with only deaf people. In addiction, they are not easily recognisable as deaf: in most cases they tend to hide their discomfort and underestimate their hearing loss, developing psychological-behavioral problems and social isolation. Because of the number of cases and degrees of hearing loss, we decided to focus the project on users suffering from medium-deep hearing loss who share the same daily use of the hearing aid, the most well-known and efficient assistive technology in the deafness sector (Apparecchi acustici Pontoni, 2019).

8.2 Methodology

The desk research has been indicative in the preliminary phase of the project because it has allowed to learn the state of the art of general assistive technologies and specific treatments addressing the hearing loss. The focus was on the following aspects: levels of hearing loss, existing hearing aids and other devices (Nidcd, 2018), ISL (Italian Sign Language, 2018), deaf social community (Affrontiamo la sordità, 2019) and forum (I sordi forum, 2019), associations and institutions.

The whole team did several interviews with experts (two graduates in hearing aid techniques from Padua) and deaf users: Luigi and Lucia, partners and parents; Michela, languages student; Ilaria, psychologist and Davide, Iuav master student.

These interviews took place at Iuav University and in different locations between Venice and Padua. All the interviews were organized to be a sort of informal conversation between the team and the interviewed, in order to make them feel comfortable in talking about themselves and what deafness represents for them: social relationships, daily life problems and critical aspects of hearing aids. After a general conversation with the interviewed about the disease, the team asked him/her some specific questions to deepen the knowledge of deafness (symptoms, personal and shared experience). In this way, by analyzing and comparing the results of the interviews, the team was facilitated in recognizing possible situations and common patterns related to the daily experience of people wearing a hearing aid.

Finally the team was able to identify a final user, which ideally sums up the main characteristics and issues identified during the interviews and the desk research: people with a medium-to-deep hearing loss who wears the hearing aid every day. In addiction, through a daily timeline analysis, the team defined some specific conditions which need to be improved, specifically related to the user who is at home and does not wear the hearing aid.

In fact there may be various situations in which the user may remove the device. The deaf person who is not wearing the hearing aid, live in a condition of deep isolation where he/she is not aware of what is happening around because he/she can not receive and process any sound information (Cappanera, 2012). The team identified the main reasons why the hearing aid is not worn: voluntary (fatigue, desire for isolation and/or concentration); induced (sleeping, places with high levels of humidity such as the bathroom and the gym); obliged (technical maintenance, cleaning of the device). Most of these situations usually occur when the user is located in a domestic environment and we analyze three of them: the morning alarm rings; a person rings the doorbell; a person wants to communicate with the user from another room in the house.

For the alarm function only one device is needed in the bedroom, located near the alarm clock on the bedside table or hung on the wall. The device does not replace the alarm clock but recognizes its sound and transforms it into a luminous feedback. One of the three lights is adjustable and can be directed towards the user's face so that the bright flashes wake him up.

For the doorbell function more than one device is needed. One of them must be located near the doorbell speaker and the others are positioned in the remaining rooms. Also in this case, the device does not replace the doorbell but it generates a luminous feedback. When someone rings the bell at the front door the specific colored light, associated to this function, turns on all the devices.

The third and last function allows family members to call the deaf user attentions when they are out of his field of view. Every room of the house can be associated with a different colored light, for instance red for the kitchen and blue for the bedroom: by pressing the call button on the kitchen's device, all the other devices will light up red, in the same way by pressing the answer button in the bedroom's device, all the other devices will light up blue. It is possible,

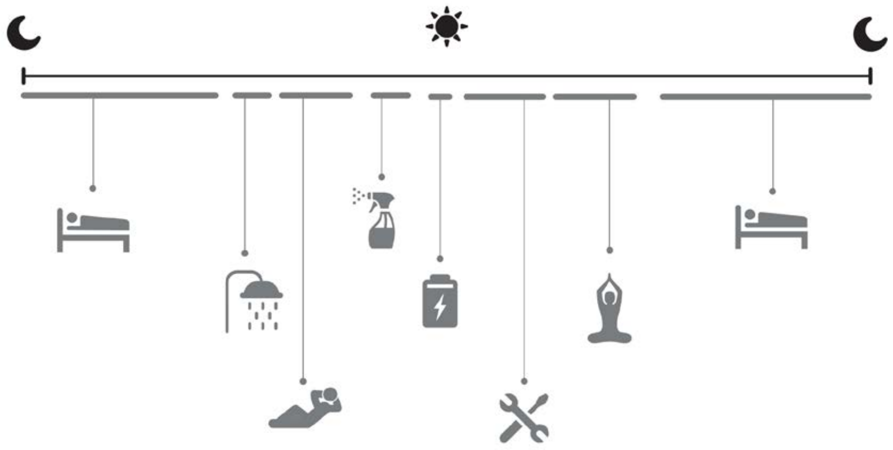

Fig. 8.1 - Journal timeline: specific situations when user doesn't wear hearing aids

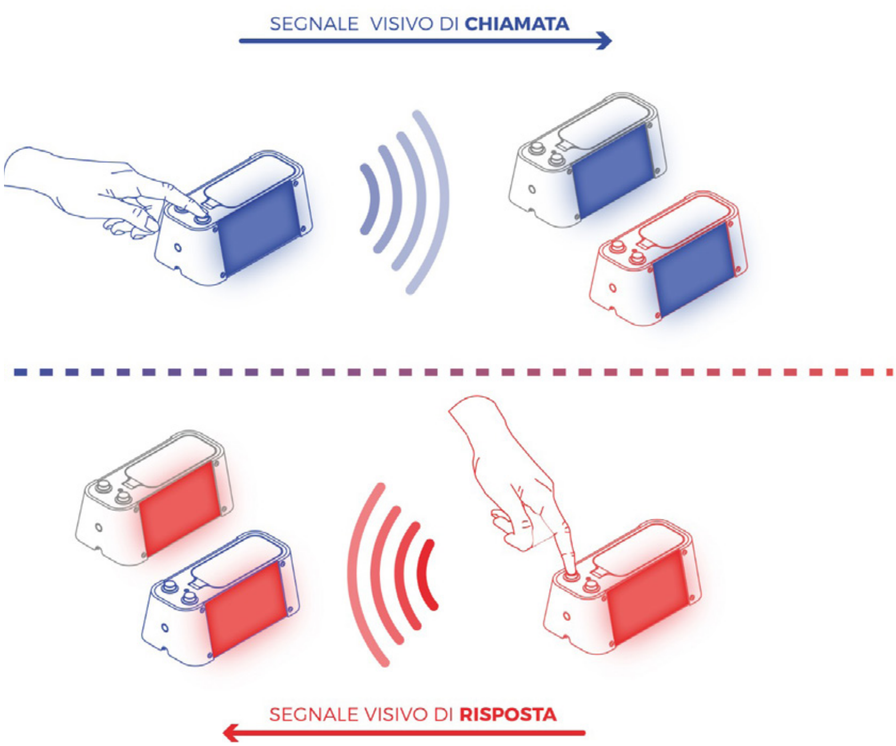

Fig. 8.2 - Colored light feedback scheme of interaction (third function)

through the answer button, to send and receive a luminous feedback that communicates the call reception.

The project development consisted in the elaboration of the feedbacks elaborated from the device (respectively the sound of the bell and alarm, and the pressure on the button) which is given back to the user as visual stimuli. In addiction the team worked on the definition of formal and functional details, such as materials, electronics components, dimensions, position, testing the prototype functionality and usability.

8.3 Results

E2E (Ear-to-Eye) consists in a open-source product that can be reproduced autonomously by the user and allows the deaf user to get feedback from the domestic environment when, for various reasons, the hearing aid is not worn or is switched off.

The project focuses on communication and interaction based on light signals in order to decrease the feeling of isolation and to facilitate social dynamics in the domestic environment. The user can have one or more connected devices that communicate each other through radiofrequency between the various rooms of the house. The devices must be positioned in a visible area of each room and through visual stimuli, the user is warned of three situations:

- the alarm clock sounds in the morning;
- someone rings the bell at the front door;
- someone from a different room is calling.

Prototype. E2E is a lighting device which can be hanged on the wall or placed on a horizontal surface. It consists of two lateral diffused lights and one central orientable light. There are two different buttons, one for the call function

Fig. 8.3 - Assembling the case components (work in progress)

Fig. 8.4 - Testing electronics and prototype functionality (work in progress)

and the other one for the answer function. The external shell has two small holes,one for the microphone and the other one for the antenna.

Downloadable and editable stickers can be used to identified the different devices and functions. Whatsmore the Leds' colour can be easily modified from the Arduino programming code. Electric components have been controlled using an Arduino Uno programmed shield and connections have been made using common instruments and material easily available on the market.

The main internal components are:

- arduino;
- electronic;
- power button;
- RF module (receiver and transmitter);
- monochrome alarm LED;
- monochrome doorbell LED;
- RGB LED for call function.

The optimization of the 3D model has concerned the following points: degree of inclination of the geometries; complete absence of printing supports (all components can be printed without waste material); minimization of thicknesses and juxtaposition tolerances.

Shared material/Instructions. An arduino code has been written to set radio frequencies communication and coloured LED emissions. E2E shell has been 3D printed because it is the best choice for a DIY open-source production. 3D files (stl and iges) and electric diagrams are available for download and can be freely modified. All the produced materials (video, photos, coding informations, various files) will be available for free in the Posta open-source platform.

8.4 Conclusion

E2E is designed for a wide range of users: from those suffering from mild to deep hearing loss. The reference context is the domestic environment but the product is designed to be modified and customized for public or work spaces thanks to the shared materials (Arduino code and 3D file).

During the design process, the team recognized some critical aspects which could be improved: the Radio Frequency module, characterized by a low receptivity, can be replaced with a wifi connection module that allows both a greater range of the signal and IOT implementations; on the microphone it is possible to set a single threshold that does not allow the device to detect sounds with different amplitudes so a voice recognition module would be a bet-

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ter alternative to create a personal library of sounds. These two aspects could improve the performance and expand the adaptability of the product.

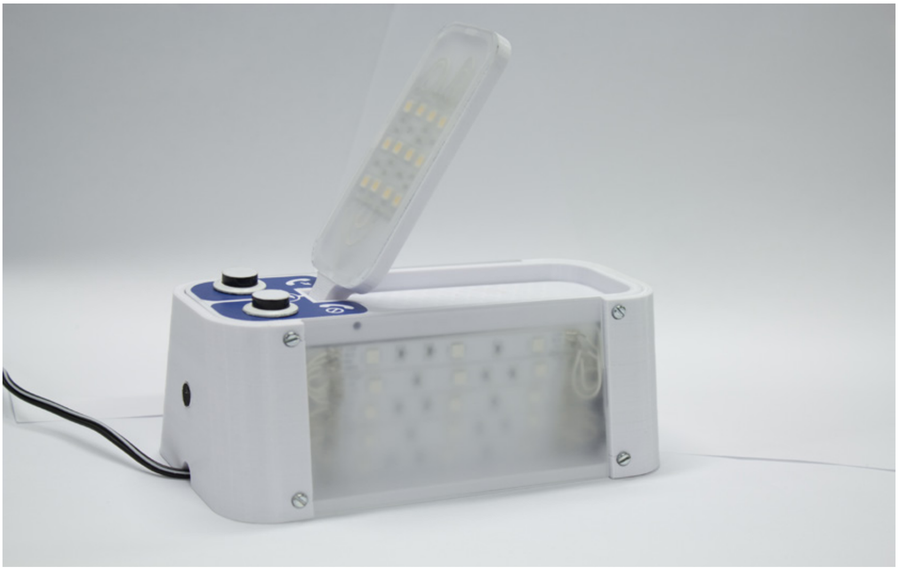

Fig. 8.5 - Opened and oriented central light

Fig. 8.6 - Communication between devices

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We wish to thank professor Medardo Chiapponi, assistants Francesca Menghi and Giovanni Borga for the supports. We also wish to thank all the people who has been interviewed and took part in the research process: Michela, Davide, Ilaria, Lucia e Luigi.

E2E is a product designed by Alice Forestan, Camilla Antea Erba, Denny Roncolato, Juan Teruel Tera and Sebastiano Cicero, product design students at the first and second year of the Master at Iuav University.

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9. Design and Prototyping for Disability. WARNI Case Study

by Michel Bertrans Casella, Lisa Casula, Iacopo Cecchetto, Enrico Rossi, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the methodology applied for the development of Warni, a night alarm for people affected by ALS. The project was developed during the "Intelligent Products" Design Studio, of the Product Design Master Course at the IUAV University of Venice (Romero, Ferrari and Toso, 2018).

WARNI was designed for ALS (Amyotrophic Lateral Sclerosis), a neurodegenerative disease that leads to the immobilization of all the muscles of the body except the eyes.

According with UCD approach (Norman and Draper, 1986), end-users has been involved in the design process. In collaboration with AISLA (Italian Association of ALS) patients and caregiver communication during night as been recognized as a key problem.

The research is carried out in an Open-source project that allows people affected by ALS to call the assistance of the caregiver during the night-time: it consists in an alarm activated by the movement of eyes of the user that sends an audible alert on the app installed on the caregiver's smartphone.

The system is based upon an infrared eye-tracking to allow the use during night time, when other communication devices are switched off.

The basic idea also brought attention to the materials used in design and prototyping, finding many useful features in an existing product, specifically the Jansjö lamp by Ikea, in which we found many favorable structural features that, through elaborations and the addition of some electronic components and some 3D printed pieces, allowed us to obtain a reproducible object.

Keywords: *Amyotrophic Lateral Sclerosis, User Centered Design, Eye tracking, Design Open Source, Learning Experience, Hacking IKEA.*

9.1 Introduction

Amyotrophic Lateral Sclerosis – ALS (Kiernan *et al.*, 2011, pp. 942-955), also known as Lou Gehrig syndrome, is a creeping neurodegenerative disease in the adult caused by the loss of spinal, bulb and cortical motor neurons, leading to the paralysis of voluntary muscles and involving also the involuntary ones.

Motor neurons are the cells responsible for the contraction of voluntary muscles in charge of movement as well as of vital functions such as deglutition, phonation, and breathing: their degeneration brings to progressive paralysis of the muscles they innervate[1].

9.2 Background

In people affected by ALS cognitive and sensory capacities remain unimpaired in the majority of cases. The average number of people affected by ALS amounts to 5-7 cases out of 100.000 per year, thanks to the improvement in diagnosis of the disease. In fact, only in Italy, there are about 5000 cases.

The incidence is about 1-3 cases every 100.000 people per year. Post diagnosis life expectancy is on average about 3-5 years, though its progress has different phenomena in each patient.

Due to the great heterogeneity of the disease, diagnosis is still problematic and, at the moment, there are no effective pharmacological therapies which can stop or slow down the illness.

Possible consequences of ALS are:

- Dysphagia, difficulty in deglutition;
- Dyspnoea, difficulty in breathing;
- Muscular atrophy, reduction of muscle mass causing the loss of muscle functionality;
- Dysarthria, difficulty in verbal communication;
- Muscle spasticity, pathological increase of muscle tone at rest causing muscle stiffness and, as a consequence, progressive slowing down and impossibility of movement[2].

9.3 Methods

The main methodology used in the development of the project was the "double diamond method" (Design Council, 2005) which is mainly characterized by four phases:

1. identification and discovery of the issue and the problem by collecting a lot of information in an objective way (divergent phase);
2. definition of priorities and precise identification of the problem to be solved (convergent phase);
3. development and conception of the greatest number of solutions on the problem, without assessing their feasibility (divergent phase);
4. selection of the most suitable solutions for solving the problem, with the aim of creating a prototype as a response to the problem (convergent phase).

Course methodology has been mainly based on the interaction with the patient/user, in order to find a solution to real problems.

This has been developed through/following specific steps:

- general research;
- contacts with the user;
- research on the state of the art;
- brief definition and following concept;
- models;
- project development;
- final working prototype.

9.3.1 Problem Identification

The final stage of ALS causes the almost complete immobilization of the patient, making him/her progressively non-autonomous and much more dependent on other people, equipment, and systems.

Thanks to the meeting with dr. Gioia Marcassa, occupational therapist at the San Camillo Hospital IRCCS (Lido di Venezia), and Andrea Ranza, President of the AISLA Association of Venice, we have identified several problems (connected to the daily assistance).

Communication Limitations. At the advanced stage of the disease, when communicating with the patient becomes difficult[3], are used ETRAN tablets[4] or PCs equipped with eye-tracking display and systems. Physical tablets are often self-made, whereas more sophisticated technological systems are disposable on the market. Later on, the SSN (Sistema Sanitario Nazionale/National Healthcare System) should provide patients with technologic communication systems/devices (tablet + eye tracking device).

Loss of Autonomy. The weakening of muscles llimits the use of arms and gradually disables the patient from autonomous feeding, destabilizing the conviviality during meals[5].

Collars/Impacting and Uncomfortable Supports. The weakening of muscles diminishes the possibility of keeping the neck erect. This requires the use of collars, often uncomfortable, difficult to fit, that enhance the unability to make various actions (for example, feeding).

Invasive Ventilation Masks. The progressive weariness of the muscles in charge of breathing obliges patients to appeal to external ventilation systems[6] for several hours a day. Often they are scarcely conformable, and uncomfortable for long-term use. At the beginning ventilation masks are not particularly invasive, but can then cover the whole face and finally can lead to tracheostomy.

Following the confrontation with the experts, we have chosen to concentrate on the first problem, that is COMMUNICATION.

The patient can't keep an easy and quick connection with the persons around her. This is particularly relevant during nighttime, when the majority of communicative devices are switch off and there is no direct way to communicate with the caregivers, that need to stay awake and watch the patient.

Thanks to the collaboration with AISLA Association (Venice), we have come to the conclusion that a device designed for night use could help to improve the life quality of people suffering from ALS, of their familiars and their caregivers.

9.3.2 State of Art

The development of the project was based on the discovery and direct study of open source projects that fulfill the communication needs of the patient in the final stage of the disease. There are several open source projects on the web giving accurate and detailed information about how to create a cheap/low cost eye-tracking device. One of the main reasons is the high cost of machinery/equipment, up to ten thousand euros. We have identified Eyewriter7 as interesting case study to start our research. The basic idea of the project is to develop a low cost technology allowing all creative talents suffering from ALS to go on designing and divulge their art, by using their eyes. Eyewriter consists in a customized software allowing people suffering from ALS to communicate through their eyes. Originally, the design consisted in a pair of glasses. Later on, the project was developed as Eyewriter 2.08, by improving the device precision and allowing it to be employed by people still able to move their head, unlike the original Eyewriter, which had been designed to be fitted on stock-still head.

Eyewriter 2.0 uses a PS3 IR sensitive TV camera (computer and software connected), and an infrared system on its sides through an adjustable wooden frame, to simplify the calibration.

The second open source project, foundational for the concept development, was Eye Motion Tracking9, which detects eye movement through two IR sensors placed on a plastic sheet and connected to the eyeglasses frame. The distance between the two sensors is given by the eye's own width. When the iris draws near a sensor, the reflected light decreases and the sensor ratio grows. Vice versa, when the iris distances itself, the reflected light grows and the sensor ratio of the photo-reflector decreases.

9.3.3 Brief

Considering the issues emerged from the comparison of the two systems, we have set some fundamental points on which proceed for the development of the project, in order to keep the users' real needs at the core of the design process.

People suffering from ALS gradually find themselves in critically growing conditions, forced to change their lifestyle and to adapt themselves to the disadvantages of the illness, therefore it is important to preserve the psychological sphere without underestimating it.

Our goal was to design a project that didn't enhance the embarrassment of the patient and helped him/her to feel included. The choice of adopting a non-invasive intervention followed this line of thought, so the project needed to neither vex nor hider the patient and the assistants as a preliminary requirement.

- **Preserving the dignity:** a device which does not embarrass the patient in his relationship with himself and the other people.
- **Non-invasive:** a device which does not vex the patient and does not hinder the movements of those who assist him/her in the various actions and moments of the day.
- **Easily adjustable:** the patient, due to repeated movements during the day, is obliged to repeat calibration.
- **Usable without display:** to prevent the patient from being annoyed by the brightness of the display during sleep.

- **Usable night:** a device allowing to read the eye movements in the dark.
- **Low cost:** a device everybody may avail oneself.

9.3.4 Concept

After a deep analysis of the existing projects we have defined the concept, based on the second of the existing projects in the state of the art, that is the one employing two IR sensors detecting eye movement and transmitting it through led lights.

The aim is that of starting from the analysis of the *Eye Motion Tracking* mechanism, in order to use it as a practical basis to then develop and adapt it.

Once identified the problem to solve, that is the communication between patient and caregiver during night hours, we have proceeded to the development of simulation models.

Given the goals defined within the brief, we have thought of a small, non invasive device easy to use for the patient and for the caregiver, both for moments of need and for calibrating options. The necessity of creating an object at a minimum cost derives from the fact that the open source project should be within everyone's reach, unlike the technologies used by current market. Thanks to the two sensors positioned near the eye of the patient, a process of immediate alarm is triggered through tracking of the eye movement. This makes the alert reach the caregiver instantly.

9.4 Results

After three months of iterative process of research-design-prototype and test with caregivers, the final result was WARNI.

Warni does not require a pc display, its peculiarity being the very possibility to instantaneously transmit an alert through an application on a smartphone, in a more versatile way. It discreetly integrates itself in the environment, and does not embarrass the user. The structure of warni is based on an IKEA floor lamp, Jansjö, chosen for the accessibility of the product in different parts of the world and the low cost. As a whole Warni is cheap, since it is built with low cost and easily available components. Its assemblage is available to everybody; it is enough to follow the instructions to assemble it.

The device is easy to calibrate and to use. It is enough to focus the pupil through the hole in the viewer and move the eye sideways until the validation leds light up. Then the alarm will be activated and transmitted to the caregi-

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ver's smartphone with a repetitive sound/tone, as if it were an alarm clock. The possibility to immediately alert the caregiver allows both him and the patient to face the nighttime more serenely. Moreover, Warni does not disturb the user's sleep because, unlike pcs, it does not shed intense light, but only a faint led light when in use.

Warni project envisages bluetooth interaction between Arduino and the caregiver's smartphone, as well as an apart connection through walls, thus enabling the caregiver to move from the patient's room. This is facilitated by a dedicated app allowing to activate the alarm through the input sent by the patient with his/her eye movement.

The sensors in the viewer detect the movement and transmit the input to the Arduino connected to the caregiver's smartphone, that rings until the caregiver switches it off. The alarm may be activated through the eyes, and also with a light brushing near the two sensors: this allows the adaptability of the project to the different physical condition of the patient. If he/she can still move his/her fingers, he/she can use the touch mechanism, otherwise his/her eyes will activate Warni through the eye-tracking modality.

The device versatility is fundamental in the case of neurodegenerative disease, as it allows to employ one's physical functionalities as far as possible.

The viewer is hold up by a foldable arm allowing the user to adjust it in height and grade. The arm is made up with a stiff base on the ground, and an arm that can be folded or moulded according to the needs of the patient and the position of the bed. The device is little invasive, and may be folded through a cogging joint mechanism to be stowed away during the day.

9.4.1 Prototype

Warni (Fig. 9.1) consists in three main elements: the IKEA Jansjö lamp, three 3D printed pieces and the electronic components. To build the prototype, the lamp needs to be disassembled and modified, and the pieces printed following the digital models provided with the project.

Then, the electronic components are assembled following the instruction and the app, previously downloaded, set up on the caregiver's smartphone.

9.5 Conclusions

The project follows the open source philosophy and therefore the list of materials and instructions to build a prototype are made available on the italian-argentinian cooperation project “POSTA” (Progetti Open Source di Tecnologia Assistiva)[10].

Warni is an assistive technology that can be reproduced freely but is not certified as a medical device.

Fig. 9.1 - Warni, final prototype

Acknowledgments

Warni is a product designed by Michel Bertrans Casella, Lisa Casula, Iacopo Cecchetto, Gonzalo Infantes and Enrico Rossi, product design students at the first and second year of the Master at IUAV University. The authors would like to thank the complete teaching staff of the course: Prof. Medardo Chiapponi, Prof. Giovanni Borga and Francesca Menghi. The authors would like to thank dr. Gioia Marcassa, occupational therapist at San Camillo Hospital IRCCS (Lido di Venezia) and Mr. Andrea Ranza, president of the AISLA Association of Venice.

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Notes

[1] AriSLA, "Che cos'è la SLA?".

[2] AriSLA, "Che cos'è la SLA?".

[3] AssiSLA, "Difficoltà di parola".

[4] AssiSLA, "Tavolette per la comunicazione ed Etran".

[5] AssiSLA, "L'alimentazione".

[6] AssiSLA, "La respirazione".

[7] Free Art and Technology (FAT), OpenFrameworks and the Graffiti Research Lab, "The EyeWriter".

[8] Thesystemis, "The EyeWriter 2.0".

[9] HomeMadeGarbage, "Eye Motion Tracking Using Infrared Sensor".

[10] Website: www.postaproject.org.

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10. Design and Prototyping for Disability. PROTIUM Case Study

by Giulia Forza, Matteo Galeotti, Laura Sguotti, Francesca Toso, Maximiliano Romero

Abstract

The present paper introduces the methodology applied for the development of Protium, a low cost prosthetic foot for children assisted in the Sulaymaniyah Rehabilitation And Social Reintegration Centre of Emergency, in Iraq.

Nowadays in Iraq a high percentage of the population is affected by landmines and, in particular, children need a constant replacement of the prosthesis due to their growth, which impacts on the life quality and on the healthcare costs.

We have designed Protium in order to be made inside a rehabilitation center, where operators can replicate the prosthetic element with machinery and materials available at a low cost in Iraq, increasing the independence of the center in agreement with Emergency's ethics.

To guarantee the quality of the device, we have analyzed the users and walk's biomechanics with the support of experts from Emergency and Orthomedica; then we have examined low-cost prosthetic feet cases and some innovative projects. A further step was the focus on the materials, we analyzed the stress on elements in order to identify these materials with the best properties to accomplish our aim.

The result of the research consists of the design for a prosthetic foot for children, made with a low budget and an high level of efficiency. The production of the prosthetic element uses reusable appropriate materials and integrates the local potential. Moreover, Protium is designed to be an open source project that everyone can benefit on: all the steps of production can be reproduced easily, making it accessible to everyone.

Keywords: *Prosthetic Foot, Life Cycle, User Centered Design, Learning Experience, Design Open Source.*

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10.1 Introduction

The relevance of design contribution in the field of assistive technologies and the possibility to have an insight on the work done by the team of Emergency[1] in the centre of Sulaimaniya (Miccio, 2018), drove us to approach the problem of the production, customization and care of prosthetic elements substituting feet of amputees due to landmines in Iraq. Our research focused on how to make prosthetic elements more accessible. The methodology consists of a first phase of research to understand the psychological and physical problems caused by the amputation of the lower limbs. In addition, the way Emergency operates in the Iraqi rehabilitation centre and how prostheses are made has been studied. Secondly, the materials available in the area were studied to understand their technical characteristics and their possible use. Subsequently, the design of a low-cost children's prosthetic foot and the related production process was achieved. Finally, Protium was tested in order to verify the correct functioning and behavior of the materials with the help of expert technicians and biomedical engineers. The objective of the project is that these prosthetic feet should facilitate walking and be easy to make, with easily workable materials and waste materials available in the territory. With these aims, we have designed a low-cost product that is accessible to a larger number of people.

10.1.1 Production of Prostheses

It was necessary to analyse the different phases of prosthesis production in the Sulaimaniya centre in order to understand the process. It was essential to understand the needs for prosthetists and doctors in order to achieve these limbs, and it was crucial to know Emergency's willingness to make the different centers independent in order to teach local people to manage the center itself. The whole process does not differ much with the western production processes, still remains based on the experience and skill of the technicians, and involves handwork and crafting making it closer to artisanship than to industrial processes.

10.2 Methodology

For us the possibility of dealing with the issue of prostheses with the support of Emergency and the experience of the technicians at the center of Sulaimaniya has been an opportunity to face a purposeful design challenge: understanding and improving the production of prostheses, using materials available in the area, being able to control production waste and making the product as economical as possible.

We had the opportunity to meet a doctor from this association who has worked in the area for many years and knows perfectly the difficult situation, and through this exchange he helped us to direct the course of the project. Our aim was therefore to make the centre independent from external suppliers, in order to remain in line with the values of Emergency, which promotes the independence of the premises. The element needs to be bought externally because of its complexity: the previous trials to product the element on site have been abandoned because the production was too expensive. Given these premises, the objective of the project is to design a prosthetic foot which can be made within the rehabilitation centre. The definition of the user was complicated by the impossibility of going to Iraq to know and see how the population lives.

However, a series of researches are made to understand the characteristics of the Iraqi population and the people affected by landmines within the area have been analysed. The data about hospitalised people (year, sex and type of amputation) from the centre have been taken into consideration in order to understand the target of the project. From the official data, it can be seen that in the last twenty years the largest number of people in hospital have been amputated in the lower limbs, especially in 2018 patients with amputation of the lower limbs are 232 against 102 of the upper limbs: this has allowed us to understand the area on which to focus. It should be noted that many of the hospitalized people come from the city of Mosul following the recent attacks by ISIS.

Further research has been conducted to understand trends, demographics and other epidemiological characteristics of patients injured by landmines.

Inside the document "Landmine injuries at the Emergency Management Center in Erbil, Iraq" (Shabila, Taha and Al-Hadithi, 2010), data show that the average age of patients is 26.5 ± 13.2 years (range 6-71 years), 95.1% are almost 50% are between 19 and 35 years of age and 96.8% are civilians. About 72% of the victims suffered limb amputations; 58.6% of the lower limbs and 13.3% of the upper limbs of the total.

Emergency's contact, who worked for a few months in the Sulaimaniya centre with some local technicians, highlighted also the frequent need for replacement in children due to their rapid growth as a common problem.

It was also considered useful to analyse the growth curves of children in general in order to have a comparison with data on children in war zones zones

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Tab. 10.1 - Details on limb amputations

Type of injury	No.	(%)	Remark
Upper limb amputation			
Below elbow	11	(3.9)	
Hand	25	(8.8)	
Fingers	2	(0.7)	
Total	**38**	**(13.3)**	
Lower limb amputation			
Above knee	16	(5.6)	
Below knee	87	(30.5)	
Foot	57	(20.0)	
Toes	7	(2.5)	
Total	**167**	**(58.6)**	

(Hosseini, Carpenter and Mohammad, 1998). For this reason, a wide range of growth curves of European males and females from 0 to 18 have been studied, based on data from the WHO (World Health Organization).

A further step was to identify the relationship between the size of the foot and the growth understood as an increase in kilos and variation in height. In order to do this, it was decided to analyze the size of the prosthesis in the current market, because, in many catalogues, including online, it is possible to set the weight of the patient and consequently obtain the specific size of the foot to be used.

10.2.1 Biomechanics of the Foot

It was considered necessary to study the biomechanics of the foot (Imeri and Mancia, 1979) in order to better understand the pace cycle, the functioning of the walk and the various joints (Hutton and Dhanendran, 1979).

The gait cycle during walking has as its purpose the movement of the subject, and in particular the locomotor apparatus performs some important functions:

- generation of a propulsive force;
- maintaining postural stability;

- absorption of the shock caused by the impact with the ground;
- energy conservation during previous functions to minimize muscle effort.

For our project it was necessary to study:
- step cycle;
- support phase;
- oscillation phase;
- flexo-extension;
- the reaction forces on the ground.

10.3 Results

10.3.1 Prototype

The evolution of the project has been functional to the improvement of some aspects to respect some fundamental characteristics for the correct functioning of the prosthesis. This was also possible thanks to the comparison with Orthomedica, a company in Padova specialized in the production of orthopaedic aids, including lower limb prostheses. Thanks to the strength tests carried out on the model and thanks to the considerations, some aspects of the foot have been improved.

1. The apex of the curve of the underlying plate has been retracted in order to align with the knee as in the correct alignment of the present anatomy of the body.
2. On the back a nylon belt has been inserted that limits the deformation of the C curve at the time of the flexion of the walk.
3. On the back a nylon belt has been inserted that limits the deformation of the C curve at the time of the flexion of the walk.
4. In order to maintain greater adhesion between the sheets.
5. The heel has been slightly flared in order to accommodate more the flexion of the C.
6. On the lower part, the rubber parts have been inserted.

A low-cost 21 cm long children's foot was designed, which corresponds to about 36 cm.

Shared Materials/Instructions. In order to choose the material for the manufacture of the structure of our prosthesis, an analysis of the materials used during the manufacture of the prosthesis was carried out. The foot prosthesis

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must have sufficient rigidity to support the child's body weight during the entire cycle of steps, a certain elasticity, good resistance to atmospheric agents and the lowest possible weight. Many production techniques are considered inappropriate to the technology available on site have been discarded, for example 3D printing and carbon fiber (Mora and Mercedes, 2007).

Considering the materials analyzed on the basis of their strength, low weight, low cost, recyclability and availability in Emergency, Polypropylene was chosen as the material of manufacture of the structural part of the prosthesis. The low density of PP allows the production of lightweight products with a high elastic recovery capacity. It has high impact resistance, high rigidity and is easy to recycle and reuse.

The cushioning element, located in the heel of the prosthesis, consists of a sheet of Ethylene Vinyl Acetate (EVA). Its elastomeric characteristics allow it to absorb the impacts produced during activities such as walking or running.

After some checks carried out during the meeting with Orthomedica, it was decided to place two metal plates (1 mm thick) between the heel and the heel of the prosthesis. The purpose of these plates is that the force exerted on the entire structure is evenly distributed over the entire heel of the prosthesis. In order to extend the service life of the prosthesis, a nylon strip has been inserted at the back between the upper plate and the lower part of the prosthesis, which limits the deformation of the polypropylene C – element of the central part.

The sole of the prosthesis is made with a tyre, in this case a motorcycle, which due to its ability to adhere to any type of soil or surface, allows the prosthesis to be used both inside a shoe and in any type of soil.

Fig. 10.1 - Protium and its components

Production. The aim of our project was that all the material used were all reusable, thus defining the production method and the end of life in order to recover some materials and to find a new life to the waste materials present in the area. In particular, production can be divided into two main phases: the recycling phase phase (Galvis Gutiérrez, 2014) and the production phase.

Tab. 10.2 - Material properties

Polypropylene (PP)	Melting point	160 °C
	Breaking strength	35,8 MPa
	Tensile modulus of elasticity	1600 MPa
	Compressive strength	12 MPa
Ethylene Vinyl Acetate (EVA)	Density	0,952 g/cm3
	Flexural modulus	10 MPa
	Shore A hardness	75
	Shore D hardness	32

Recycling phases:
1. shred the polypropylene with the Shredder;
2. extrude the PP bar;
3. cut the bar into smaller bars.

Production phases:
1. place the bars in the oven at 190 °C for 15 minutes;
2. insert the heated bars into the mould for 40 minutes;
3. pressing the mould;
4. open the mould;
5. stretch out the slabs and drill holes in them with a drill;
6. cutting and drilling the tyre;
7. cut the heel from a slab of EVA and shape it;
8. assemble the components with the belt inserted in the upper part;
9. complete the assembly with the bead and the part of the tyre behind.

The main feature of the project is the standardized and artisanal process. We decided to completely revise the production process of the foot elements in order to be able to make the prosthesis inside the prosthetic center.

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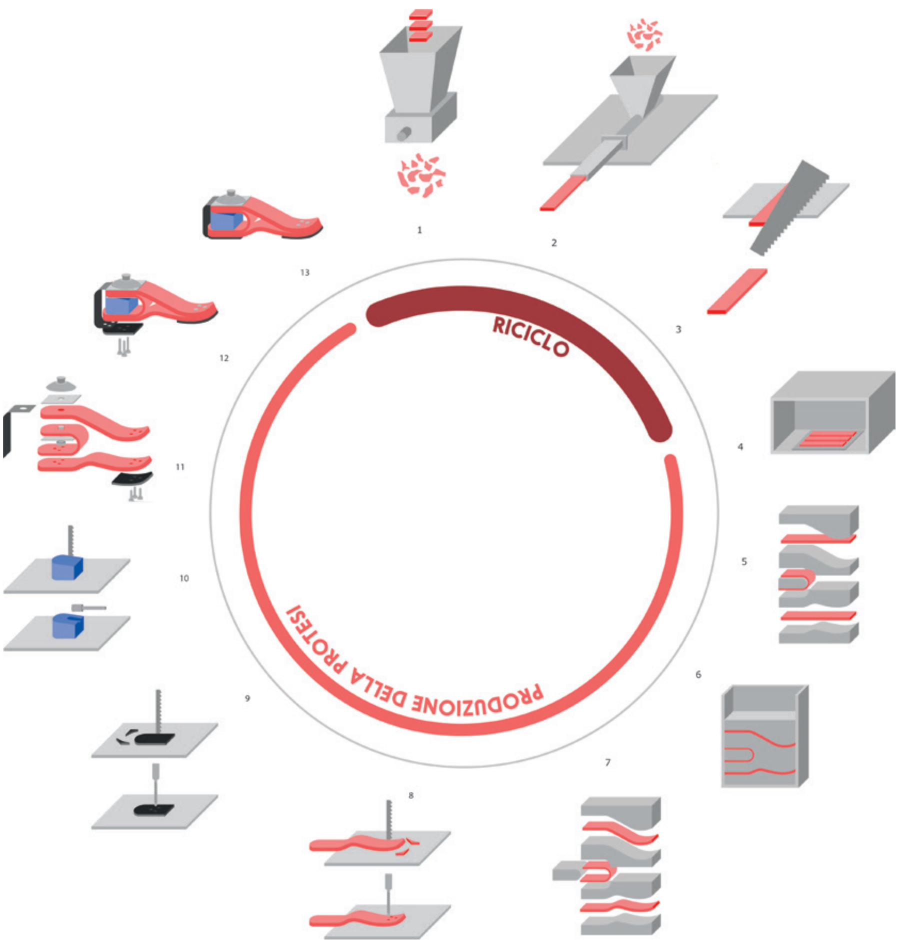

Fig. 10.2 - Production process of the prosthetic foot

In particular, the recycling phase was inspired by the Precious Plastics project (Hakkens, 2018), which promotes the recycling of plastics through the construction of hand-made machinery for recycling in an open source project.

Customization. We wanted to make the prosthesis customizable, because it was interesting to see how each child is able to customize their own prosthesis. To customize the prosthesis we decided to modify the plastic itself: through the insertion of elements, such as wire meshes, it is possible to create a texture on the surface by pressing the mold.

Structural analysis. It was decided to apply forces (placing a load of 700 N) on the points where the maximum load is applied during the walk, it was simulated the deformation of the material both at the level of stress and displacement, thus finding that the prosthesis supports the forces applied.

Cost analysis. Considering the cost of raw materials directly from suppliers, the material cost for the prosthesis is €3.66, a sum that can be reduced if waste or recycled products are used for EVA, steel, nylon and tyres.

In addition to the materials, the cost of the machinery that will be purchased for the realization of the recycling phase of the prosthesis has been considered.

The possibilities of purchasing Precious Plastic machines are:

- the purchase of already assembled machines for a total cost of 3400 €;
- the purchase of equipment for the assembly of the machine on site for a total cost of about 100 + 250 = 350 €, without considering the labor.

The cost of the machinery is then amortised on a forecast of 250 prostheses (lower limb prostheses produced in 2018): 13.60 € cost of the machinery for each prosthesis.

It is also necessary to include the cost of labor working on the project, assuming an hourly rate of 7 euros and a time of 3 hours for the production of each prosthesis: 21.00 € is the cost of labor for each prosthesis.

At the end of the first year, the cost of the machine will be covered, from that moment on the final cost of the prosthesis will be lower.

The prosthetic foot has been compared with those on the market and with those already used by Emergency. Protium is a foot with lower costs than those of current prostheses, offering significantly higher efficiency than the classic wooden foot currently in use.

Tab. 10.3 - Table with cost of the prosthesis

	Final cost of the prosthesis in the first year	Final cost of the prosthesis after the first year
Raw materials	3,66 €	3,66 €
Machinery	13,60 €	-
Labour	21,00 €	21,00 €
Total	**38,26 €**	**24,66 €**

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10.4 Conclusions

Protium is a prosthetic foot for children that is made at a lower cost than the cheaper prosthetic feet, but offers the same efficiency as the mid-range prosthetic feet. It has been designed to accompany the user's walk as much as possible and the relative distribution of forces during the step cycle.

The design choices were all made with a view to circular economy: the materials to be used are easily available at low cost or can be waste materials. The evaluation of the materials was in fact dictated by the desire to use materials that can be reused and adapted to the possibilities of the Iraqi territory, but also efficient and adequate in terms of mechanical properties. In this way, the design of a prosthetic foot has been achieved, which over time will come at a very low cost. Protium was therefore designed within a logic of circular economy to avoid waste and waste as much as possible and, since one of the objectives is the possibility of production on site, the prosthetic foot is easily assembled and reproducible. These two characteristics make it possible to insert this project within an open-source logic and therefore to share information. In order to do this, the entire production method of this prosthetic foot has also been studied: all the manufacturing phases of the individual components have been standardized in order to simplify production as much as possible, which is so serial. Therefore Protium is a prosthetic foot for children that can be assembled in a few steps, reproducible, inexpensive but still very efficient.

Acknowledgments

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Notes

[1] EMERGENCY is a non profit organization founded in 1994, recognized as an NGO partner of the United Nations and that remains independent and neutral. It was founded to offer free, high quality medical and surgical care to victims of war, landmines and poverty. Emergency has been present in Iraq since 1995, when

the programme was launched, and since then 941,116 people have been treated. The active programmes on the territory are different. In Sulaimaniya there is a rehabilitation and social reintegration centre to offer assistance and a self-sufficient life to people amputated by landmines. www.emergency.it.

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11. IRIS – Blind Assistive for Identification of Indian Currency Notes

by Mani Teja Lingala, Mrudul Chilmulwar

Abstract

India currently has around 12 million blind people – which makes India home to one – third of the world's blind population. The blind has great difficult in identifying Indian currency notes. Notes have "supposedly" raised tactile identifier markings like squares, circles, rectangles and triangles. These markings tend to fade out over time due to wear and tear, making it an inefficient method. While new notes have identification marks on their sides, they are not easy to make out. Demonetization of Rs 500 and Rs 1000 currency, introduction of new notes and co-existence with other old notes created more issues for the blind.

As a part of the course work "Design for Special Needs" at National Institute of Design (NID), India. We considered this issue as a challenge to address their needs. After doing extensive research on the behavioral aspects of the blind such as their ways of intersection with the currency notes by deepli, we understood that most of the blind people do comparative identification of currency with reference to the size. We came up with a simple yet useful method that will help visually impaired people identify currency notes. A simple template (credit card size) which doesn't cost more than Rs 5 (0.064 Euro). The user simply needs to keep the note over the template and can identify the denomination based on its length (by steps) and width (by notch). The solution incorporates categorization of notes into 3 different sets (Old low denominations 5,10,20 / Old high denominations 50,100 and New notes 50,200,500,2000) and a simple rule to understand the template is the higher the step, the higher is the denomination in that set. The solution therefore is very simple and has been designed to identify notes in the least possible. The solution is designed to be able to easily be carried in a wallet/pocket. The solution is designed to unobtrusive so that blind people don't feel hesitant to use it on public places. Both the old and the new notes can be identified using IRIS. Also, the solution is flexible enough to incorporate any new notes that might be released by the government, i.e the solution can be adapted to identify newly released notes too with small changes still retaining its simplicity and ease of use.

The solution can be easily be distributed by agencies working for the blind as the cost of making one unit is very low (not more than Rs 5). This ensures that it remains accessible so that it could reach the maximum number of people. IRIS can be manufactured at source of distribution ensuring involvement of the local people.

Keywords: *Blind, Assistive, Demonetization, Currency*

11.1 Introduction

As part of a course "Design for Special Needs" by Dr. Gayatri Menon during 4th semester of our master of Product Design, we students were meant to work closely with people with special needs/disabilities to improve their quality of life through product, service or system interventions. We decided to work with blind people and tried to identify ways to make their life easier.

11.1.1 Global and Indian Scenario

According to a paper published on 2 Aug 2017 in the Lancet by Vision Loss Expert Group (VLEG) estimates that there were 36 million people who were blind globally. Further, 217 million people live with severe or moderate visual impairment (MSVI). In total, 253 million people were living with visual impairment in 2015. It also estimates that 1.1 billion people have nearvision impairment – a condition that can be corrected with spectacles. 89% of visually impaired people live in low and middle-income countries, 55% of visually impaired people are women.

India is home to one third of the blind population of the world with over 12 million blind people out of which over 60% lives in rural areas with no or less accessibility to eye hospital or clinic. Of all the cases 75% of these are cases of avoidable blindness, due to country's acute shortage of optometrists and donated eyes for the treatment of corneal blindness.

11.1.2 Day to Day Hurdles

A Blind person in his day to day life faces great deal of problems from walking in crowded places, crossing roads to getting into public transport and buildings, finding the right direction, interacting within the public place. Unlike west, India has still not done any significant design changes in the public transport, public buildings, parks, roads to make it disabled (specially Blind) friendly. But still each of this problem has some or other ways of work around to a certain extent, but one such crucial problem is neglected for so long i.e. Identification of currency notes, blinds has great difficult in identifying Indian currency notes. Although government has took deliberate measure during the designing of the currency notes by adding some distinguishing features to make it visually impaired friendly, some of the features worked but some didn't. Features that failed to perform are tactile marking and embossed numbers done by intaglio printing technique to help blind people distinguish different denomination of bank notes. Features that work well are the use of bright colors of the notes which helps people with low vision to distinguish different notes. Still the problem of identifying the currency remains as it is.

11.2 Background

It was already difficult for visually impaired person to identify different denomination of Indian currency notes despite having tactile marking on it for identification of these notes.

On 8th November 2016 the situation got even worse as Indian government declared that currency notes of denomination 500 and 1000 will no longer be in circulation and new currency notes of denomination 50, 200, 500 and 2000 will come in circulation. The newly released currency notes of denomination 50, 200, 500 and 2000 has different set of dimensions compared to old currency notes of denomination 10, 20, 50 and 100. This created confusion for visually impaired people to distinguish between old and new notes and correctly identifying the denomination of the notes. They have memorized the different denomination of old currency notes by their dimensions (length and width), but he introduction of the new notes had made it difficult for them to distinguish it from old notes. As some notes has same length, e.g. Old 20 rupee note has same length as New 200 rupee, that's double the value; Old 10 rupee note has same length as New 50 rupee note that's 5 times the value.

Around 550 petitions were filed in High court and Supreme Court of India by numerous activists, individuals, NGOs, organizations working for visually impaired, but no action was taken by the government. People with 100% visual impairment require notes with different sizes and tactile marks that can they can feel easily by touching the currency note. Individuals with low vision need contrast colors and large fonts to identity currency note denomination. However, "Most of our bank notes and coins are difficult for the blind to identify. The new notes have multiplied the challenge. Digital currency still remains inaccessible though they can use computers and apps using assistive technology" the Petition says. We considered this issue as a challenge to address their needs.

11.3 Methods

To tackle this problem we needed to understand entire ecosystem from how visually impaired person makes transactions every day to what are currently available technology and techniques used in other countries to address this issue. To do so we followed this process.

Identifying the Problem. Mapping all the issues faced by visually impaired person in a daily basis, ranking them according to severity. Selecting one on the basis of this criterion: urgency of attention, availability of other solutions for same problem, how often a person faces this problem? The selected problem was the difficulty of identifying different denomination of Indian currency notes after introduction of new notes.

Understanding the Cause of Problem. Identifying what makes it difficult to identify the one note from other (considering the fact that we cannot redesign the note now, as it's already in circulation and we have to deal with it). How helpful are those tactile markings on the currency notes? How long the tactile marking last before it get faded?

Understanding Mental Model of the User. Carefully studying how visually impaired person interact with the currency note? How they use to identify old notes? Understanding their ways of handling the currency notes. The insights we found are:

- they compare length and width of a known currency note with unknown currency note to identify the denomination;
- comparing length of currency notes with the length of middle finger from the base of their palm;
- comparing folded (from center) currency notes with the size of their palm;
- putting the note between their fingers to check the width of the note;
- holding the note between two hands to check the length.

They have established their own relationships based on dimensions of currency note. "They need a reference (palm, fingers, hand, known currency note) to compare the dimension of currency notes to identify it correctly" this is deeply rooted in their subconscious and is almost second nature for visually impaired person.

Fig. 11.1 - Comparing length of note with length of their palm

Fig. 11.2 - Comparing width of the note with length of their fingers

Fig. 11.3 - Comparing the dimension of unknown note with known note

Ideation. To explore different ways to identify currency notes it was important to understand the anatomy of the note, such as its texture, color, dimension, electrica conductivity and weight.

Few of the concepts were:

- a mobile app to identify the currency note based on image mapping;
- a sensory watch to identify reflected light from currency note to identify it, as each currency note will reflect it differently;
- a hand held scanner to scan a small portion of currency note when kept on it to match the note with the database;
- a tactile template which acts as a reference to compare the currency notes;

After doing feasibility study for all the concepts and directions from insights the conclusion was:

- any solution with sensors and other technology will cost more and will be unaffordable for most of the people;
- any app base or smartphone dependent solution will not reach to most of the people as 60% of blind population lives in rural area and not everyone has a smart phone;
- any technological solution has to be handled with care, learning curve of the new technology is more as they will have to form a new mental model in their subconscious.

The selected concept was the tactile template that uses “comparison of dimensions of currency notes with its own dimension” to identify the currency note, which is similar to the existing mental model of visually impaired person of comparing the dimension of currency notes with their hands, finger etc.

Prototyping and Testing. The prototype is made in various materials like card board, mill board, PVC sheet and Polypropylene sheet to find the most suitable material for use and easy of mass production. After testing the product in various materials in various conditions and comparing proscons of each one, the final selected material was PP (Polypropylene) sheet.

The prototype is rigorously tested with the user with the help of BPA (Blind People Association, Ahmedabad, India) and improvements are made according to the feedback. All the available denominations of the Indian currency notes (Old: 5, 10, 20, 50, 100 and New: 10, 50, 100, 200, 500, 2000) currently in circulation can be identified using our solution.

11.4 Results

The decision of going tactile instead of use of technology paid off as the learning curve and acceptance of the solution by the users is more on positive side. The solution works by categorization of notes into 3 different sets (Old note with low denominations 5,10,20 /Old notes with high denominations 50,100 and New notes 50,200,500,2000) and a simple rule to understand the template (product) is the higher the step, the higher is the denomination in that set. The solution therefore is very simple and can identify any currency notes in the least possible steps.

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Tab. 11.1 - Analysis of prototype features

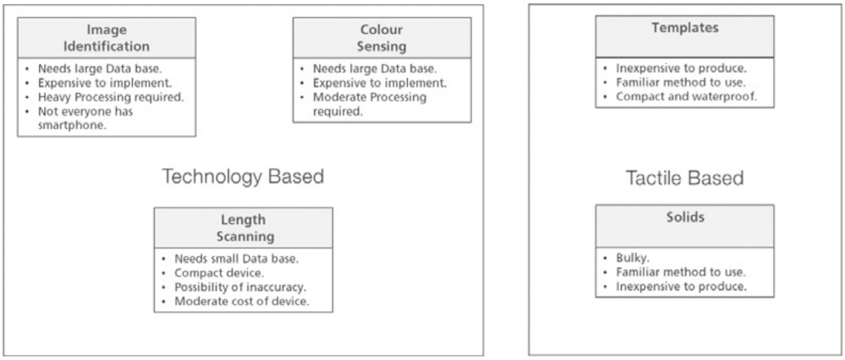

Fig. 11.4 - Prototype

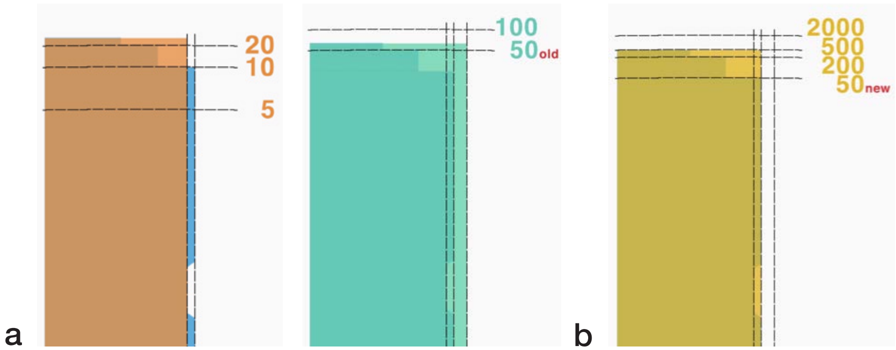

Fig. 11.5 - Relationship between the template and the currency notes: a. On left are old notes low denomination of 5, 10, 20 and on right is old notes high denomination of 50 and 100; b. here are all the new notes of 50, 200, 500 and 2000

11.5 Conclusion

Identifying the Indian currency notes is a difficulty faced by blind people in India, demonetization of Indian currency note and introduction of new notes made this situation severe. Despite the new design of currency notes with special tactile markings to help blind identify this notes, it failed to solve the issue. Blinds people have developed their own ways of identifying the notes that uses comparison of dimensions of notes with their palm, fingers and other notes. By tapping their existing mental model of comparing size to identify notes we derived a tactile based compact template, which acts as a reference to identify the unknown currency notes. After extensive user testing and refining, the final product according to end user is easy to learn and is capable of identifying all the available denominations of old and new Indian currency notes in circulation as of now. The product is been supported by Blind People Association (BPA), Ahmedabad, India. Despite the support from BPA and their efforts to make it available to their community of blind people, we need more and more collaboration to make this solution available across India.

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12. Mobility System for Hippotherapy: the Development Process

by Guilherme Neto Ferrari, Bruno Montanari Razza, Maria de Lourdes Santiago Luz, Paula Conceição Rocha de Oliveira, Maykon Cesar Spolti Ferreira, Flavio Clareth Colman, Bruno Isamu Obana, Lucas de Oliveira Brancalhão

Abstract

Hippotherapy is a method that uses the movements of the horse as a therapeutic tool for patients with neuromotor system disabilities and difficulties (Lessick *et al.*, 2004). The professionals of a hippotherapy center, besides other activities, assist their patients to mount and dismount the horse, representing an activity of high biomechanical efforts and causing discomfort (Boaretto *et al.*, 2018). According to Evanoff *et al.* (2003), it is possible to reduce this physical stress at the transfer of patients by using assistive lifting systems. Therefore, this article presents the design steps of the development of an equipment to help the center of hippotherapy, considering usability and user satisfaction, according to Iida and Guimarães (2016), and all the agents: hippotherapy professionals, patients and horses.

The data collection generated Ergonomics requirements that were considered by the development team, composed by designers and engineers, at the alternative generation and refinement. By the use of focus group method, according to Baxter (2011), the final solution was validated, providing the detailing needed for the final alternative and highlighting the need of elaboration of tests with scale models and functional prototype.

Keywords: *Hippotherapy, Ergonomic Equipment, Patient Transfer Lift, Industrial Design Process.*

12.1 Introduction

Hippotherapy uses horse movement as a therapeutic method for the psychosocial development of people with special needs, integrating areas of health, education and horse riding, in which the professional adapts the cadence, acceleration and direction of the horse to the practitioner (Debuse, Gibb and Chandler, 2009).

There are several health conditions that can benefit from hippotherapy, such as children with Down syndrome who improve their walking (Copetti *et al.*, 2007); women with multiple sclerosis who presented greater independence (Lessick *et al.*, 2004); and people with different traumas, who had improvement due to the relationship with the animal (Yorke, Adams and Coady, 2008).

However, few studies evaluate the physical and health conditions of hippotherapy professionals. Ergonomics is a science that studies and guarantees a safe and adequate environment for workers, reducing risks, increasing productivity and quality of service, finding solutions to avoid accidents and occupational diseases (Waters, 2010).

Ergonomic studies performed at a hippotherapy center in the city of Maringá, Paraná, Brazil, have demonstrated high biomechanical efforts, discomforts and ergonomic risks in the professionals' activities (Luz, Boaretto and Rodrigues, 2017). The intervention solution was the development of a mobility system that helps transfer the practitioners to/off the horse, an activity that requires more effort, according to Boaretto *et al.* (2018).

The development of the system was carried out by a multidisciplinary team that combined their knowledge in development, dimensions, design and creativity to find the best solution that facilitates the activities of professionals, without harming the safety and comfort of the practitioner and also of the horse.

The team defined the development in four macro steps, followed by micro steps to guide the creation process. The development of the system has not yet been completed, but the team is planning tests, worrying about the prototype, analyzing flaws, and developing user guides.

12.2 Background

This article is the result of studies of a team composed of mechanical engineers, production engineers and designers, including professors, graduates and undergraduate students, from the State University of Maringá, located in Maringá, Paraná, Brazil. Called SIMOPE Project, the team developed a mobility system for people with special needs applied to hippotherapy practices.

The practice of hippotherapy involves three main agents that work in a harmonious way: the professional of hippotherapy – occupational and speech therapists, physiotherapists and educators (Léveillé, Rochette and Mainville, 2017); the practitioner, from children to the elderly, covering different conditions and special needs that affect motor, cognitive, emotional and speech functions (Lessick *et al*., 2004); and the horse, whose movements acts as a therapeutic tool (Pavão, 2015).The ergonomic problem in hippotherapy practices was perceived through Luz, Boaretto and Rodrigues (2017), who analyzed the activities of the professionals of the hippotherapy center, through the Ergonomic Work Analysis (EWA) and the OWAS (Ovako Working Posture Analysis System) and NIOSH (National Institute for Occupational Safety and Health) diagnostic tools, diagnosing biomechanical efforts, indicating risks of Work-Related Musculoskeletal Disorder (WRMD) and discomfort in various activities performed by equine therapy. The most ergonomic troubling task, according to Luz, Boaretto and Rodrigues (2017) is the transfer of the patient, in which professionals must use their strength to lift the patient from the wheelchair to the horse.

Patients transfer is much observed in the health field causing injuries and occupational diseases (Dutta *et al*., 2012). For that reason, lifting devices are used to reduce these risks, as demonstrated by Evanoff *et al*. (2003) and Collins *et al*. (2004).

Therefore, the need at the hippotherapy center, perceived by Luz, Boaretto and Rodrigues (2017) and Boaretto *et al.* (2018), can be supplied through the development of mechanical equipment for lifting and transferring the patient to and off the horse, thus mitigating the constraints of the biomechanical efforts of the professionals, keeping the practitioner safe and the well-being of the animal.

12.3 Methods

The product development is a complex process, requiring the involvement of several professionals (Iida and Guimarães, 2016). A multidisciplinary team was set up, resulting in a survey of different methodologies, since, according to Baxter (2011), it is necessary to master several techniques, choosing the one that suits their problem.

To guide the process was used the methodologies of Rozenfeld *et al*. (2006), Pahl *et al*. (2007) and Baxter (2011). The equipment must consider Ergonomics values, concepts from Iida and Guimarães (2016) were also added.

With the survey of bibliographies, a planning of the stages of the project was elaborated, using instructions of the above-mentioned authors and considering the necessities of the project. Therefore, the process was divided in four main phases, observed in Fig. 12.1 and described below.

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Fig. 12.1 - Stages of the Project. Source: Authors (2019)

12.3.1 Phase 1. Development Planning

This stage is defined by the problem recognition, identification of those involved in the development, acknowledgement of similar products and competitors. Resulting in the product scope.

In this phase, the problem recognition and identification of the ones that are affected by the product in development can be done by means of visits to the hippotherapy center so the researchers can understand the activities and efforts made by the professionals. Also, the definition of the stakeholders and market analysis can be done by talking to the hippotherapy professionals, as well as through a bibliographical survey.

The activity of similar analysis enables the visualization of existing solutions and opportunities. It can be made by studying videos, photos, instruction manuals and patents of products that are similar to the one in development.

At the end of this phase, the product has a defined scope, it means that it is defined what one wishes to accomplish with the product.

12.3.2 Phase 2. Information Collection

This phase is defined by the collection of all the necessary information for the initial design, considering users' needs, expectations and requirements, generating a list of requirements for the equipment.

By means of visiting the hippotherapy center, the activity and its physical efforts can be visualized, as well as the perceptions of the professionals and practitioners can be collected.

A bibliographical survey of authors and studies can serve as a base for the identification of requirements, contributing with concrete data and information from scientific researches. Also, visits to the center can contribute for the dimensional, structural and organic recognition of the work environment, verifying the height of the place, as well as the dimensions of free space and measures of the wheelchairs, these activities can serve as a parameter for the design of the equipment. So, through visits to the center of hippotherapy, interviews with the ones involved in the activities of hippotherapy and the collection of physical data, the list of requirements can be defined.

12.3.3 Phase 3. Conceptual Design

Based on the product requirements definition, the conceptual design can be started. This step transforms the information collected into principles of solution and initial concepts, from which refinements, improvements and modifications are generated following the needs and opinions of team members and stakeholders to achieve the best possible solution.

This stage is composed by the planning of the principles of solutions, which means to divide the product in functions and establish principles of Based on the product requirements definition, the conceptual design can be started. This step transforms the information collected into principles of solution and initial concepts, from which refinements, improvements and modifications are generated following the needs and opinions of team members and stakeholders to achieve the best possible solution.

This stage is composed by the planning of the principles of solutions, which means to divide the product in functions and establish principles of solutions for these functions. After this, the team can generate and select the best concept for each function and compose the design concept of the product.

With the concept already defined, it can be presented to the users to collect their perception and opinions, this way the team can refine the concept and make it more appropriate to the user's needs.

12.3.4 Phase 4. Detailed Project

This macro step consists of detailing the components and architecture of the product, defining the manufacturing processes and materials to be used.

The specifications of the concept defined in the previous stage can have its components and parts detailed, defining its tolerances and measures through calculations and simulation.

In this stage, the team must define what is going to be produced and what has to be bought, as well as what materials are going to be used. Tests and failure analysis are recommended to be done by this moment of the project.

12.4 Results

Next, it will be discussed each phase defined in Fig. 12.1, demonstrating what was done, the tools and methods used and the results of these.

12.4.1 Phase 1. Development Planning

In this stage the team focused on understanding the user's needs and what was the problem that the product was meant to reduce. Defining the function of the product, as well as the stakeholders of it, the team developed the product scope.

Problem Survey. The equipment seeks to intervene in the ergonomic problem of hippotherapy professionals, which was observed and studied by Luz *et al.* (2017). Visits to the center of hippotherapy in study allowed the research team to see these efforts for themselves. Therefore, the equipment is supposed to facilitate the activities of lifting and transfer of the practitioners to the horse, avoiding and reducing discomfort and those biomechanical efforts.

Market Analysis and Stakeholders. In this project, the main stakeholders are the professionals and the practitioners of hippotherapy, the center in study and other centers that can use the system.

Competitors and Similar Analysis. The analysis of similar products was made by gathering data such as photos, videos and patents of these and presenting it to the whole team. With this information, the team listed the main strengths and weaknesses of each similar product, this way discussions about structure problems, ergonomic importance and design opportunities were generated. Product Scope Definition. The above activities defined what one wishes to accomplish with product: the need to reduce the discomforts and biomechanical efforts of hippotherapy professionals; to convey comfort to the patients; to maintain the animal's well-being; and to respect the structural limits of the center.

12.4.2 Phase 2. Information Collection

Once defined the problem that the equipment is supposed to solve, as well as the user's and stakeholders, the team started to collect all the information needed to generate the requirements to develop this product.

Identify Users' Needs. The hippotherapy activities involves three different users: the professionals, the patients and the horses, all acting together. All of their needs needed to be considered to the product development, this way the team interviewed the patients to understand how they feel about being transferred to the horse with an equipment. Also, the team talked to the professionals about their activities and about the horse's behaviors towards a new equipment. Identifying and listing their needs. These talks can be visualized on Fig. 12.2.

Survey About the Context. To understand more about the hippotherapy context, learning what are the needs of the practitioners and the necessities of the horses in this kind of therapy, the team made a lot of bibliographical researches, which helped with the definition of requirements. Also, the team was able to identify a lack of equipment that could suit the specific needs of the hippotherapy center.

Requirements. From the aforementioned collections, the requirements defined were: the equipment should be efficient in the ease of handling, operation

Fig. 12.2 - Interview with the users. Source: Authors (2019)

and cleaning; comply with the dimensional limits of the hippotherapy center and must be foldable, retractable or detachable; do not exceed noise limits established by standards; to present biomechanical comfort to the hippotherapy professional; be safe in an emergency and not perform sudden movements near the horse; avoid the fall of the practitioner and not distance him from the hippotherapy professional. Pleasantness aspects were also considered, as it is said by Iida and Guimarães (2016), where its aesthetics must present blue tones and cannot symbolize the shape or movements of predators.

12.4.3 Phase 3. Conceptual Design

With the requirements already defined, the team can start to develop the initials concepts of the product, by dividing it into functions, generating alternatives of solution to each and every function and, then, doing some refinements to get to the better final product form.

Planning the Principles of Solutions. For the concept generation stage, Baxter (2011) said to establish principles on the operation of the product, configuring a coherent synthesis to guide the generation of alternatives. According to the author, this should generate basic principles of the product. Thus, it was established two options of form and operation for the solution of the problem:

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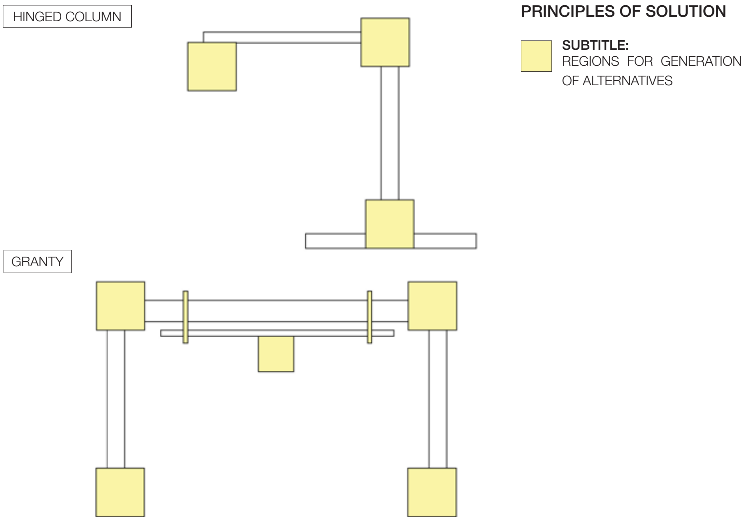

Fig. 12.3 - The principles of solutions. Source: Authors (2019)

a gantry and a hinged column, as shown in Fig. 12.3. From this it was possible to generate different alternatives for each of these two options.

Concepts Selection and Generation of New/Expanded. After defining the two principles of solution, the parts of the equipment were segmented, making possible the use of the tool of morphologic analysis, as said by Baxter (2011). Also, the SCAMPER (Substitute, Combine, Adapt, Modify, Purpose, Eliminate, Rearrange) technique was used, where the team was stimulated to mix the components making combinations for new ones, as shown in Fig. 12.4 (Baxter, 2011). The team performed an evaluation of the alternatives created to select the best ones through evaluation criteria that considered the safety and Ergonomics of the users, as well as the ease of manufacturing and handling of the equipment. This way, some refinements, improvements and expansions were carried out.

Refinement of the Main Concepts. In order to collect user perceptions and opinions, it was used a focus group, which is recommended in phases of analysis, synthesis, creativity and detailed design, as shown in Fig. 12.5. This method can help to select the best solution or give new ideas for a model or prototype (Pazmino, 2013).

Thus, there was a synthesized presentation of what was done in the project since its inception: researches carried out, requirements generated, alternati-

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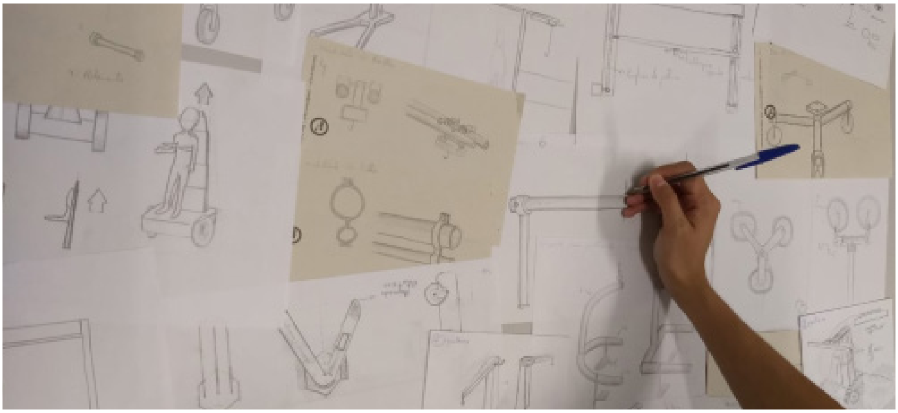

Fig. 12.4 - Creative Process – Generation of alternatives. Source: Authors (2019)

Fig. 12.5 - Focal Group at the Hippotherapy Center. Source: Authors (2019)

ves, details of the final alternative and renderings. It allowed the collection of new perceptions, such as: concerns about energy consumption, the weight of the equipment and the adaptation of the horse. From the perceptions, it was opted for the development of a real-scale volumetric model for tests.

Baxter (2011) quotes the importance of using fault analysis tools, which aims to predict potential equipment errors and minimize or eliminate their occurrence. Thus, a real-scale volumetric model was used to test horse risk and the resistance simulations of the structure were made in a software.

12.4.4 Phase 4. Detailed Project

With the concepts already done, selected and refined, the product can have its structured detailed, as well as its production defined and specified. This way, at the end the product can be produced and tested.

Detailing the Structure. The specifications of the concept defined in the previous stage had been carried through, detailing and improving the components and parts by 2D and 3D drawings, defining its tolerances and measures by calculations and simulation.

Production Specification. It was in this stage that the team defined that most of the materials that would be used in the final product were steel or aluminum, and that most of the parts and components needed to be produced and some parts, like the electric system and the lifting system could be bought. As the equipment is still under process of patent, there's no figures to show it completely.

Tests and Failure Analysis. The product development has not been fully completed; the project team is in the process of developing the prototype. From the prototype will be carried evaluation with the users, testing, development of use and maintenance manuals and risk analysis to improve the use of the equipment.

12.5 Conclusion

The planning of the stages allowed a systematic control of the development process, generating assertive results, helping the team to understand the activities and tools of each of the stages.

The project is in the patenting situation of the equipment, elaboration of the user manual and usability tests. It is intended to finalize the project with the provision of an equipment that effectively improves the activity of the professionals of hippotherapy, reducing pains and efforts and respecting the horse and the patient.

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13. Role-Playing Living Lab (RpLL) Method: Increasing Maker Empathy Through User-Generated Content of Role-Playing Activities

by Eunmi Moon, Sheila Schneider, Deana McDonagh, Lisa Mercer

Abstract

Numerous interventions have been designed to build empathy, not only to learn how to empathize, but also to motivate people to understand. The focus of this research is to support both makers and users in enhancing empathy building through long-term engagement in co-creation. This study is mainly concentrated on proposing the Role-playing Living Lab (RpLL) method as a means of facilitating the maker's experience of users. At the heart of RpLL is a role-playing activity co-created by the user and maker, to be experienced by the maker. The user facilitates for the maker, while the maker acts like a real user, and has a first-hand experience by putting themselves in the setting of a user's situation and condition through role-playing. The significance of this research is in the validity of the RpLL method incorporated into the entire Design Thinking process. As a result of the primary studies, the factors garnered provided an invaluable foundation for role-playing guided by the real user. This study answers the question: How could a user and a maker work with one another at the front end of the design process to find ways to understand and empathize with the needs of the users?

Keywords: *Empathic design, Co-creation, Living lab, Role-playing.*

13.1 Introduction

A variety of methods have been acquired over the years to help makers build empathy that will help them deeply understand the User Experience. "User experience" encompasses all aspects of the end user's interaction with a design solution; its goal is to meet the exact needs of the user (Norman and Nielsen, 2016). However, there must be an opportunity of maker experience "of

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users" to reach authentic User Experience. Moore (2015) spent time in the late 1970s as a woman in her 20s wearing a set of "aging" prosthetics to have the experience of someone in her 80s. The insights she gained made her one of the founders of the Inclusive Design movement, and prosthetic outfits are now stock in trade of empathic designers (Moon *et al.*, 2019). The prosthetic gears and devices are sufficient enough to develop empathy notwithstanding, our research team had a chance to develop a new method for the creation of interactive empathy building between maker and user through long-term engagement for co-creation. This method aims to focus on extending the replicability aspects in other sectors, specifically in the design for inclusion and in teaching and learning relationship in the long run.

Many individuals have visual impairments; however, people who are blind/legally-blind (B/Lb) have specific diseases and disorders that make it imperative for them to have assistive devices to live independently. Individuals who are B/Lb were selected as a user group, and researchers in the field of design put themselves as a maker for the first case study of this research. Makers and users as a team together named "GuidingMe" as a title for their first case study.

This research presents works done by some existing living labs, completed role-playing activities done elsewhere, and their findings. The qualitative user study and secondary research about living lab and role-play are examined and evaluated to support how the Role-playing Living Lab (RpLL) method was prototyped and implemented. It further describes how the user engages with the maker through the RpLL approach and also presents how the maker finds ways to understand and to empathize with the needs of the user in the front end of the design process with a focus on experiential concerns.

13.1.1 Motivation for the Research

The main motivator for the start of this paper is the result of researches that prThe initial research question was: "How can designers understand and empathize with the needs of blind users to create a mobile application with easier accessibility?" In the initial response, makers brought together creative ideas and making skills to develop a prototype mobile application focused on the navigation system for the user group of B/Lb. However, when the research team approached the user community to recruit volunteers to test the prototype, the user group turned down the proposal due to a lack of empathic connection and trust which arose from negative experiences in the past with other research groups. Most of them never completed what they promised the users at the beginning of the research (Fig. 13.1).

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In gratitude, the research team had a chance to be introduced to a real user. They began meeting regularly and continued to do so over the past two years. The user even introduced the research team to their online community where the team has received valuable feedback from the various interviews and surveys (Fig. 13.2).

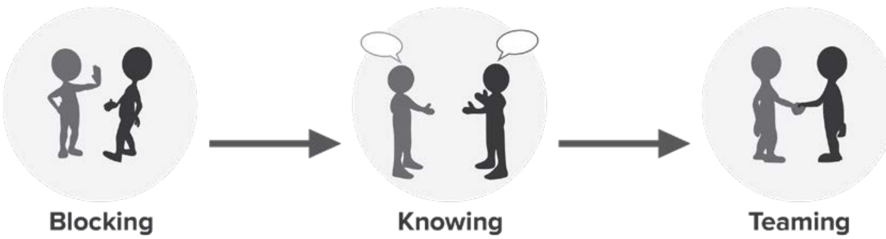

Fig. 13.1 - RpLL Method Stage 2-Teaming: Transition of maker-user relationship

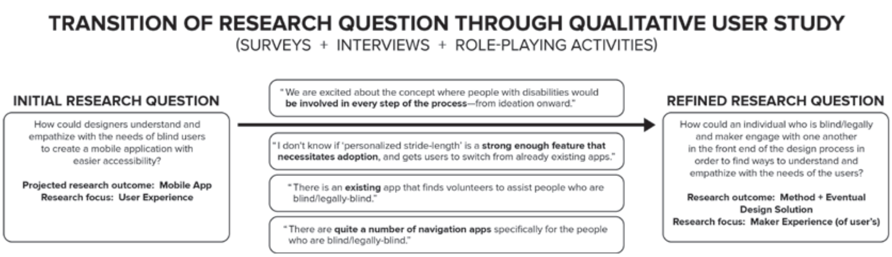

Fig. 13.2 - The transition of the research question through a qualitative user study

While building a relationship with the user group, the users are creating multiple role-playing activities based on their issues and needs for makers' empathic modeling experience having a VI and experiencing an actual user's lived experience.

An intrinsic lesson learned as a maker from this experience is that building long-term relationships with users that goes beyond one-time — from the beginning, throughout, and even after the project — is the first step of knowing your user deeper and as thoroughly as possible. Furthermore, it is the accountable mindset of a maker. Thus, the research team realized that makers need some set platform and method to have quality opportunities of experiencing their user's way of living rather than relying on their assumptions and making similar products repeatedly. Consequently, a new research question was refined from the initial question: How could an individual who is B/Lb and a maker engage with one another in the front end of the design process to find ways to understand and empathize with the needs of the users? The answer was that this engagement could be managed through role-playing activities created by the blind user for the maker, and that constitutes a new method of engagement for an empathic maker experience, leading to better outcomes from the maker (Fig. 13.3).

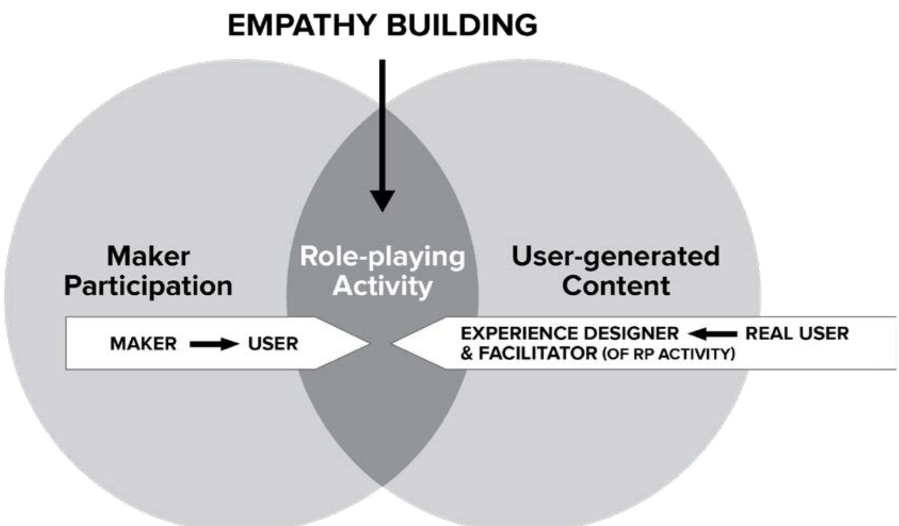

Fig. 13.3 - Diagram of RpLL showing the role of maker and user

13.1.2 Potential Benefits: Maker + User = Empathy

In this research, the "makers" are defined as people who bring together their creative ideas, making skills, and the power to fulfill the final design solution in the process of design and production with a prepared mindset of empathizing and learning. Design Thinking, iterative prototyping, and empathic maker experiencing are key maker activities. Makers put themselves in the setting of users' situation or condition through the role-playing activity, and act like real users who are having a first-hand experience. Designers, developers, engineers, policymakers, researchers, and stakeholders, etc. could be included in this category. "User" is defined as an individual in need of a design solution under development in their everyday lives and situations to obtain a benefit or to solve a problem. The user generally does not have technical expertise.They are volunteered "real users" for the active project and contribute their "using expertise" to generate the content of the setting based on their experience. They furthermore act as a facilitator to lead role-playing activities for the makers (Fig. 13.4). They are acknowledged as a user-expert designer and an equal partner of the project.

At the heart of RpLL is a role-playing activity co-created by the user and maker, to be experienced by the maker. The user facilitates for the maker, while the maker acts like a real user and has a first-hand experience by putting themselves in the setting of a user's situation and condition through role-playing (Fig. 13.4). The significance of this research is in the validity of the RpLL method incorporated into the entire Design Thinking process. As a result of the primary studies, the factors garnered provided an invaluable foundation for role-playing guided by the real user. It further describes how the user engages with the maker through the RpLL method and also presents how the maker finds ways to understand and to empathize with the needs of the user in the front end of the design process with a focus on experiential concerns.

Fig. 13.4 - Makers with a temporary impairment cross the street guided by real user

13.2 Background: Theoretical Considerations

Suppose makers are working with the user group who are B/Lb to create a smart design solution to improve their daily lives and make things more convenient and comfortable. However, there are a vast number of products and services in spate and continually produced at this time. Rather than making similar solutions repeatedly, there needs to be some set platform and method to have a quality opportunity for makers having a first-hand experience to know their user's life deeper and as thoroughly as possible. In a world of complex problems and issues, makers and users need to work together to solve these problems with multi – and interdisciplinary approaches. Before taking that further, there must be some theoretical considerations of "user experience", "co-creation", and "empathic design" studied.

13.2.1 User Experience

It has been almost a century in which User Experience is a crucial factor in diverse fields. The first requirement for excellent User Experience is to meet the exact needs of the user. Authentic User Experience goes far beyond giving users what they say they want. The User Experience is made up of emotions and motivations. Using fictional personas, creating usage scenarios, and customer journey mapping are part of traditional methods designing User Experiences, and these methods have been instrumental in uncovering the needs and wants of the target users. The only problem with that is often, with complex issues and situations, the user may not know what they want. What they say may not entirely match what they do in reality. Great User Experience design encompasses all of these aspects but particularly grasps what the user does not realize (Raday, 2015). There is only so much we can observe or ask the user. These include the hidden desires of users; their latent feelings; and the future experiences of people, communities, and cultures (Ibragimova, 2016).

13.2.2 Co-Creation

Co-creation is a practice of collaborative creativity to enable innovation and create value "with" users and stakeholders, who are involved in the process. Designing a solution with the user is the primary purpose of the Human-Centred Design, and co-creation is based on the belief that the users' participation is essential in the design process and requires an active engagement of all actors in the process. Users are now informed, connected, and empowered on a scale more significant than ever before, and their empowerment has resulted in a change in the roles adopted during their experience and has given rise to user co-creation (Ramaswamy, 2008). While the Design Thinking method contributes to creating value through in-depth user observation, co-creation method aims at creating value through user interaction (Hemonnet, Fabbri and Manceau, n.d.). By involving real users in the Design Thinking process, makers learn early in the process whether the creative idea or solution will be successful with the users. Co-creation approach helps to uncover the exact needs and wants of the users. Involving users in the innovation process increase their engagement in the project, and enable smooth communication and interaction. Users can become part of the design team as "expert of their experiences", but for them to take on this role, they must be given appropriate tools for expressing themselves. Incorporating the user/expert into a design team assists the designer in expanding their empathic horizons as well as informs the design process. Nevertheless, it is important for makers to consider a boundary line between makers and users in the process of Design Thinking and production.

13.2.3 Empathic Design

Empathic design is the process of developing a holistic understanding of users (Empathic Design, 2016). Quesenbery (2010) defines "empathy" as "*[…] the ability to understand and identify with another person's context, emotions, goals, and motivations*". Developing a design solution with the user and the ability to empathize with users is an essential part of the Human-Centred Design (Ibragimova, 2016). Makers are directly responsible for both the functional and emotional needs of the users (McDonagh, 2015). "Empathy" in human interactions, especially in Design Thinking, development, and production process, is an increasingly important factor in design society nowadays. With most design solutions used by a various range of user groups, makers must develop an understanding of how to design solutions that appeal to, support and enable users (Empathic Design, 2016). By collaborating closely with users, makers can begin to respond to their authentic needs, identifying design solutions within the users' real-life environment (McDonagh *et al.*, 2013). Researching users in such a way is to help designers identify their users' fundamental needs. When makers establish users' needs, they can develop new problem-solving approaches that accommodate the users' constraints and utilize their capabilities. The ultimate purpose is to improve the user's experience by modifying the design solution to their explicit, implicit, and latent needs (Empathic Design, 2016).

13.3 Methods

In this research, "role-playing activity" and "living lab" are applied as methods to be utilized to create a new approach.

"Living lab" is defined as a platform that leads the makers and users together to the successful collaborative creativity through the long-term engagement for co-creation, and used as one of five factors in creating a new method. A living lab is a common ground for makers and users to freely share their ideas, build empathy, and work together to co-create a better design solution. The European Network of Living Labs (ENoLL) defined the "living lab" as user-centered research and open innovation ecosystem. Living labs typically refer to co-creation and appropriation of innovations by the user, often in a community setting, and involving multidisciplinary stakeholders (Ballon and Schuurman, 2015).

"Role-playing" is an experiential prototyping approach that allows makers to explore the user's experience within the system (Dam and Siang, n.d.). The best use of role-playing is in capturing the users' emotional and motivational experience of using a design solution. Makers use it to gain an empathic understanding of users through simulating what they are experiencing—the memory of the experience is more explicit when it is physically simulated in an actual environment of the user.

13.3.1 Role-Playing Activities Done Elsewhere

A South Korea's Politician Becomes a Taxi Driver

Issue: two taxi drivers burned themselves to death after carpool service application is introduced and pushed toward in South Korea.

Maker: a South Korean politician.

User group: taxi drivers.

Role-playing activity: working as a taxi driver in a real setting. Maker took a test and got a taxi driver's license.

Duration of the activity: 2 months.

Conception: maker believes that it is the job of politicians to accommodate the traditional business to new surroundings for their soft landing while promoting the new businesses.

Purpose: to understand structural problems in the taxi business, and to find out better solutions to intervene between traditional and new businesses.

Obstacles: user community did not open up their mind due to a lack of empathic connection.

Ford Motor Company's Engineers Experience How It's Lik to Be Pregnant

Issue: "Get the other person's point of view", Ford has realized the best way to understand how customers interact with their product is to empathize with them. Empathy is hard to learn and difficult to teach.

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Maker: engineers and company stakeholders (Ford Motor Co.).

User group: expecting female consumers.

Role-playing activity: wearing a pregnancy simulator, "Empathy Belly" while driving.

Duration of the activity: 10-20 minutes.

Conception: company believes that it is their job to create an environment for their employees that gives the most in-depth possible insight into their customers' way of life to get to the root of the problem and craft a solution.

Purpose: to understand the customers' behaviors, attitudes, motivations, and frustrations.

Obstacles: an "Empathy Belly" is quite pricey (about $700/a set), and it probably can't simulate the emotional experience of being pregnant.

Result: allows designers and engineers to reconsider their perception (bias) about Universal Design, having that awareness of different populations, age groups, and users.

13.3.2 Benchmarks of Selected Living Labs

Malmo Living Labs at Malmo University, Sweden.

This living lab has been working with participatory design approaches and social innovation in the city of Malmo. Explorations are carried out through a design practice-based approach which entails long-term engagements with different actors in the city for the co-creation of new practices, services, and products. The researchers involved in the lab are rooted in the participatory design community and regularly work with co-creation processes involving diverse stakeholders in the area of Malmo.

The pilot project "Malmo New Media Living Lab" was a small-scale Living Lab in which new media services and products were user-generated content. Users from the various fields were engaged in developing, experimenting with, and evaluating new solutions. The method produces new experiences and practices focused on engaging grassroots enthusiasts, building upon their needs, and trying out concepts developed in a real setting.

Findings:
- participatory design approaches in a real setting;
- long-term engagement with different actors;
- participatory design community involves diverse stakeholders;
- user-generated content.

Helsinki Living Lab, Finland.

This living lab is an ecosystem of the living labs and their collaborators in the Helsinki metropolitan area. HLL helps promote user-driven open innovation through methods and tools used for improving the real-world development of products and services. It is both a communications hub and an open umbrella brand for enabling companies and the public sector to get in touch and co-create with all the different living labs and their end-users in the metropolitan area.

Findings:
- user-driven open innovation;
- communications hub;
- open umbrella for enabling various sectors to get in touch and co-create with other living labs.

13.4 Result: Role-Playing Living Lab (RpLL) Method

This section explores the concept of the RpLL method – what it is, how it has been developed, and how this practice could benefit the makers and the users in the whole design process. The RpLL method is a maker – and user-driven co-creation approach to involve and support both makers and users in enhancing empathy building through long-term engagement. This method is primarily concentrated on the maker's experience (of user's) through maker participation in user-generated content, which supports the real user in creating the content of the role-playing activity based on their experience. In RpLL method, the role of the user shifted from the passive research subject to the active content creator. Users are the best experts in their everyday lives and have great potential as sources of design solutions. The user furthermore facilitates the role-playing activity for the maker, while the maker acts like a real user, and has a first-hand experience by putting themselves in the setting of the user's situations and conditions. This new method is supported with a platform, in the form of a living lab that combines both physical and virtual space, where users, makers, and all other associates (stakeholders) meet and participate in the design process as equals. In this space, direct maker-user interaction supports turning the maker's mindset ready to understand User Experience. The significance is in the validity of the RpLL method being incorporated into the entire Design Thinking process.

As a result of the primary research, the factors garnered provided an invaluable foundation for role-playing guided by the real user.

13.4.1 Five Factors of RpLL Method

The RpLL method consists of five factors, including maker, user, living lab, user-generated content, and role-playing activity.

Maker: who brings creative ideas, making skills, and power to fulfill the final design solution (e.g., designers, engineers, policy makers, stakeholders, etc.). Makers participate in role-playing activities and act like a real user to have a first-hand experience by putting themselves in a real-life setting of users' situations and conditions.

User: who uses design solutions under development in their everyday lives and circumstances. Users volunteer for the project, and they have the freedom to choose the level of involvement in the process at the beginning. Users are expected to create role-playing activities based on their experiences and to facilitate the activities for the makers. They will be acknowledged as an equal partner of the project.

Living lab: maker – and user – driven platform that involves makers, users, and all other associates and stakeholders for a design solution co-created with maker participation and user-generated content. It is a human-centred open innovation ecosystem based on systematic co-creation approach and integrates research and innovation process in real life settings. Makers and users are equal partners in the living lab.

User-generated content: an experience design, role-playing activities, created by real users. The contents are the actual users' experiences.

Role-playing activity: activity created by real users for makers experiencing users' way of living in a real-life setting and getting a deeper understanding of users.

13.4.2 Seven-Stage Process of RpLL Method

The RpLL method takes place at the initial point of the project and incorporated into the entire Design Thinking and development process. In this process of empathy building for co-creation, there are seven stages identified.

Stage 1. Initiation: the initiation stage involves makers bring an issue, and start secondary research about the needs and problems of the focus group, the existing and competing market, and the possible solutions.

Stage 2. Teaming: the teaming stage is the most difficult due to a lack of empathic connections and a high level of uncertainty about the project. Makers search for volunteers including real users and all associates who involve in the

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Design Thinking and development process such as designers, developers, engineers, policymakers, and stakeholders.

Stage 3. Team Research: the team (makers + users + associates) establish the project, conduct various surveys and interviews, and get the permissions associated with data collection in the team research stage.

Stage 4. Role-playing: the real user designs a series of experiences for makers to develop empathy, and makers play a user role in a real-life setting in the role-playing stage. Quick writes followed right before and after the role-playing activities by makers.

Stage 5. Ideation: the entire team brainstorm ideas and focus on the challenge in the ideation stage.

Stage 6. Prototyping + Testing: makers create rough prototypes for testing, and get the users' feedback in the prototyping and testing stage.

Stage 7. Production: makers propose a viable solution and have secondary ideation to refine prototype and retest. A successful final solution is produced in the production stage.

13.4.4 "GuidingMe" Project: A Case Study with a User Group of Blind/Legally-Blind

Individuals who are B/Lb were selected as a user group, and researchers in the field of design put themselves as a maker for the first case study of this research. Makers and users as a team together named "GuidingMe" as a title for their first case study. Throughout two years of in-depth study, the research question transmuted, and the focus of the research is changed from a design solution to a design method.

Data collection for this research involved surveys, interviews, and role-playing activities through direct interaction with users on a one to one basis or direct interaction with users in a group setting. Makers and users, together as a team, created a survey to garner information from real users about their experiences with smartphone use. The survey determined if the user has a visual disability, their age, what type of phone is being used, and what kind of applications the users use on their phone. The team interviewed a user to discuss her survey responses. The follow-up questions were to address the user's day-to-day living. The role-playing activities completed as part of the research reveals quite a bit about the emotional angst that individuals with visual impairments feel when encountering new spaces or planning trips to places they have never before traversed. The role gives a very accurate portrayal of how a person with visual impairments can feel at the end of a day of these types of encounters. Once makers experience a role-playing activity, they then gain empathy and just a minute amount of understanding of the cumulative experiences of a person who is blind/legally-blind. It is imperative in a research setting to try these experiences several times to experience different situations a maker may have to get a broader range of options or areas in which to work for a solution (Fig. 13.5). The qualitative data collection method is time-consuming; therefore, data is collected from a smaller group that would go for quantitative approaches. The benefit of the qualitative approach is that makers could get more productive results for the research and have a more in-depth insight into the user group. For design researchers, prototypes most often fall into the experimental category, where specific features of the prototype are tested, not on the path toward a complete design solution, but instead toward a better understanding of an idea about the future (Ruecker and Roberts-Smith, 2018).

13.5 Conclusion and Future Work

The potential benefit of this research is to support both makers and users in enhancing empathy building through role-playing activity in a set of co-creation platform called "living lab". The vast amount of research/methods previously studied/conducted focused on the User Experience but NOT on the maker's experience of the user. Thus, the RpLL method for the empathy building is introduced by applying "role-play" and benchmarking "living lab" in this study. This study is mainly focused on proposing the RpLL method as a means of facilitating the maker's experience of users. At the heart of RpLL method is a role-playing activity co-created by the user and maker, to be experienced by the maker.

Fig. 13.5 - A maker navigates with the help of a guide dog played by another maker

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The user facilitates for the maker, while the maker acts like a real user, and has a first-hand experience by putting themselves in the setting of a user's situation and condition through role-playing. As a result of the primary studies, the factors garnered provided an invaluable foundation for role-playing guided by the real user. The qualitative user study and secondary research about living lab and role-play are examined and evaluated to support how the RpLL method was prototyped and implemented. It further describes how the user engages with the maker through the RpLL approach and also presents how the maker finds ways to understand and to empathize with the needs of the user in the front end of the design process with a focus on experiential concerns. The significance of this research is in the validity of the RpLL method incorporated into the entire Design Thinking process.

Continued work in RpLL method aims to focus on extending the replicability aspects in other sectors, specifically in the design for inclusion and in teaching and learning relationship.

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14. Workplace Ergonomic Analysis: Activities Performed by a Computer in a Metallurgical Company

by Luiza Grazziotin Selau, Gislaine Sacchet, Carla E. de Lima, Gabriela Brunello

Abstract

This article aims at the ergonomic analysis of an office environment. For this study, the relationship of the space with the productivity, physical and emotional well-being of the employees who work in this office was made, the location in question is one of the largest Brazilian metallurgical companies, at the Garibaldi-RS unit (Brazil).

For the preparation of this study, data collection occurred through exploratory investigation, with the support of interviews, observation and recording of images of the space. The functions performed in the analyzed environment consist of performing activities in front of the computer in a workstation composed of table, chair and elements essential to the execution of the tasks, with the analysis of noise and light inserted in this context. In view of the importance of Ergonomics in the configuration of furniture and objects, the analysis of the interactions of the man inserted in his work environment, highlights the problem that companies are not always aware of all the standards or apply strategies that enable the performance of work guided by the adequacy of the environment to the needs of workers.

The observation techniques used provided the capture of all variables involved in performing the tasks. In turn, it was understood the characteristics of the layout in the distribution of furniture in environments, as well as the height of the computer, type of chair, among other factors that may or may not favor the performance of activities. As methods of recording and postural analysis, data were collected and analyses were performed through the application of the Welfare Pentacle, which is to demonstrate graphically which were the results obtained through the application of a questionnaire with the intention of understanding the life profile of the collaborator, Rula (Rapid Upper-limb assessment) was also applied, which within Ergonomics is a method that allows the investigation and evaluation of biomechanical overloads incurred during

the performance of activities within the company. Another tool used was the Corlett's Pain Diagram, which offers an opportunity to observe employees in their midst and through questions about the incidence of pain establish a parameter. Finally, the analysis of anthropometric variables allowed for checks related to L.E.R. (Repetitive Effort Injuries) and D.O.R.T (Work-Related Musculoskeletal Disorders) disorders, which are directly linked to a lack of quality in the performance of the work. Thus, it can be seen that the analysis provided a greater understanding of the issues related to Ergonomics, related to physical, emotional and organizational aspects.

It was also possible to realize the importance of the application of Ergonomics within organizations, in order to provide employees with a work with dignified conditions for a minimum journey of eight hours daily, five days a week, as is the case of the company analyzed. It is recommended that the company not only maintain the current working conditions, but accentuate the care directed to employees, to further increase productivity, since the company applies and pays attention to the ergonomic aspects analyzed according to the results of the tools applied in the study.

Keywords: *Ergonomic analysis, Ergonomic assesment, Productivity, Well-being, Workstation environment.*

14.1 Introduction

Ergonomics is concerned with observation, research and analysis of the adaptation of work to the needs of man, not restricted to work performed through machinery and equipment, but in all situations. Ergonomics goes beyond the physical environment of the individual, because it also talks to organizational and cognitive issues, having as a characteristic the breadth of coverage. Therefore, ergonomic studies should be thought of as an activity of planning, control and evaluation of work possibilities (Iida, 2005).

The human being in all their interactions puts a little of himself; his experience, his limitations, his desires and abilities, therefore, the "*characteristics found in all people should be considered independent of the object to be projected*" (Klafke *et al.*, 2013). In the sphere of what is planned, one must take into account the environment where people perform their activities and interactions, valuing in a relational way man-context-object.

Proposals initially indicated by the Design project should be executed by companies providing the team with conditions to perform their work, preventing physical or emotional problems. Therefore, the analyses performed by or-

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ganizations in the face of productivity should be added to the ergonomic analysis, providing the possibility of a strategic planning, focusing on the concern with the individual (Andreto, 2005).

The present work aimed at the analysis of an office environment and physical well-being of workers on site. To this end, a case study was carried out with an employee, who was followed on her working day for one week. During the investigation, the space was related to the productivity, physical and emotional well-being of the employee who works in the office. The location analyzed was the office of a medium-sized metallurgical company, located in the city of Garibaldi, Rio Grande do Sul, Brazil.

14.2 Metodology

For the preparation of this case study, it was necessary to perform data collection for further analysis. The information was collected through descriptive, cross-sectional (Bordalo, 2006), qualitative research. According to Gil (2008), the descriptive research aims to observe, record and analyze the phenomena. It is a cross-sectional research, which according to Aragón (2011), is an instantaneous study of the population at a given time. Qualitative research, which according to Duarte (2002), are forms of research that analyze the information, in view of their quality.

The information was collected in stages, first with an interview for the collaborator who agreed to participate in the study. For Lakatos (2003), through the interview it is possible to obtain the necessary information about the subject under study, through social communication, both for data collection and for diagnosis or intervention of the problem.

Once the observation and interview phase was concluded, records were made with images of the place, to then follow the analysis stage, from the recorded observations of the environment to the interviews.

14.2.1 Methods of Recording and Postural Analysis

For detailed analysis, in addition to the interviews, some data collection tools were applied, which allowed a better understanding of the scenario, including the variables related to the employee in question.

Ergonomic analysis is extremely important for the early detection of work-related problems, as well as possible solutions when the confirmed picture is of some type of trauma resulting from the activities of the individual (Lima, 2003).

For this reason, we adopted the already validated instrument on Nahas' lifestyle (2003), the Well-Being Pentacle (SBP), a tool whose purpose is to extract a conceptual basis for the evaluation of the employee's lifestyle.

The Rapid Upper-limb assessment (RULA) was also applied, a method that allows the investigation and assessment of biomechanical overloads on the employee in the performance of their activities. RULA presents results obtained by observing the postures assumed by employees, and the posture of the neck, trunk and upper limbs, i.e., the arm, forearm and hands, are assessed. (UNIPÊ, 2018).

It was also observed through Corlett's Pain Scale Diagram (1976), incidence of pain by excessive practices of movements and postures.

The anthropometric variables allied to the conditions of the environment, furniture and performance of functions were also analyzed to verify the context and the ideal plan for the work.

14.2.2 Organizational Factors

The observation techniques used provided the capture of all the variables involved in the performance of the tasks, as well as the understanding of the characteristics of the layout in the distribution of furniture in the environment, as well as the height of the computer, type of chair, among other factors, which may or may not favor the performance of the activities. The company in question organizes its space in such a way that employees sit side by side, the

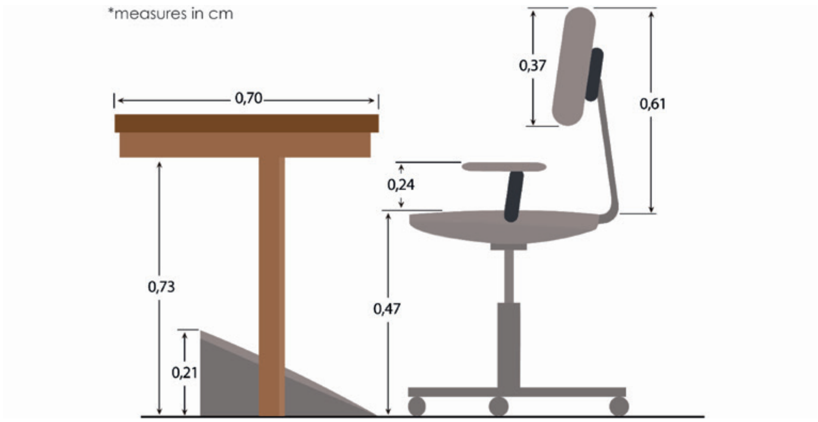

Fig. 14.1 - Representation of the chairs, table and feet support used by employees in the company

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individual space is small, thus, in view of the distribution to the environment, it is evident that there is a compromise of effectiveness, efficiency and satisfaction of employees.

For Andreto (2005, p. 3) "*no concept of workspace can be universally applied to all types of offices. Even in the same company, the spaces must change according to the business objectives*".

According to Ordinance No. 3.214/78 "in order to ensure the well-being, seats and chairs used in the company should follow some specifications in relation to height, which should

To be adjustable the measurements of the collaborator as well as the nature of his function, needs rest for the arms, providing support to the forearm and keeping it at right angles, must maintain a layout of rounded front edge, containing an adaptable backrest to preserve the lumbar region from trauma. As for the tables, they should be set aside for the windows, with height following the level of the elbows, at right angles to have the ideal measurement, so they should not be too low or too high. For Corrêa (2011), the height can vary from 720 mm to 750 mm, its depth from 600 mm to 1100 mm, the width should be 800 mm, in the case of the employee under study, the table used by her, has a width of 150 mm.

Regarding the telephone, according to Ordinance No. 3.214/78 "it is recommended that they be Headsets, since these devices are easy to handle and reach, and facilitate the execution of two functions at the same time, the range of the device used by the employee is in accordance with the regulatory standards, with a distance of 470mm from her body. This arrangement requires attention to maintenance and hygiene in order to avoid the proliferation of backgrounds and bacteria that can be harmful.

As for the monitors, they must be raised to eye height, have an adjustable base, they must be positioned at least "one arm away" to avoid that the employee's posture is during the contracted day, in the case of the employee, the distance from the eyes is 500 mm, within the parameters considered healthy. The base available to support the monitors indicates that there is a difference in size between them, but they are consistent with the structure of their users.

As far as the keyboard is concerned, Ordinance No. 3.214/78 "provides that it must be aligned with the employee's elbows". The arrangement of the keyboard on the work surface of the employee under study, is 290 mm away from the body, the user says that the distance is pleasant.

Regarding lighting, the working environment should be adequate, for Vilas (2016), an office is a considerable challenge, because it makes use of printed materials next to monitors, while the first ones ask for a higher illumination for full understanding of the information, the second does not require high bright-

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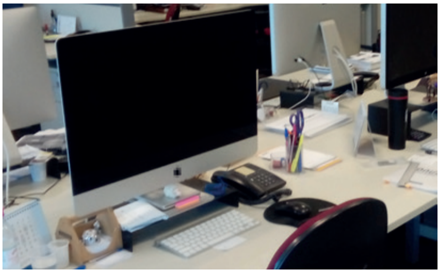

Fig. 14.2 - Monitor

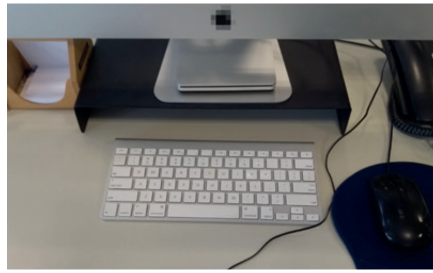

Fig. 14.3 - Support of the monitor

ness in the environment. Low or high brightness can cause several types of disturbances, and the psychological illness is especially severe, because the individual starts to feel negatively influenced (Open, 2018). It was verified that the company under analysis respects the precepts of NR17.

Regarding noise, following the instructions of NBR 10152, which estimate a variation between 30 and 60 dB, noise close to the auditory area is considered (Brazilian Association Of Technical Standards, 1990). In view of the ergonomic indications in NR17, in comparison with the parameters offered by the company, it was found that it is within the requirements.

For the execution of the work, issues such as thermal comfort and air quality must be carefully observed, as well as any other factor. With temperatures varying between 21o and 24o, considering the summer and winter factors, regarding the air in space, the relative humidity cannot have levels below 30% during the coldest season of the year, already in summer, the humidity must remain between 40 and 60%, these values are generally perceived as pleasant, regarding the air movement in these environments, it is considered comfortable the limit of 0.2m/s (Abergo, 2018).

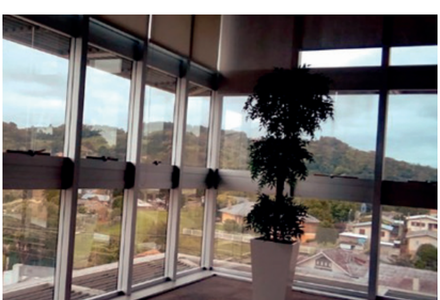

Fig. 14.4 - Luminosity

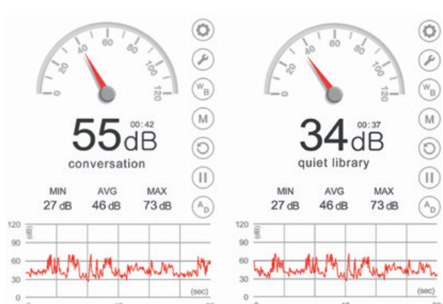

Fig. 14.5 - Noise

14.3 Results Analysis

The ergonomic study carried out showed that the functions of employees in this work consists of performing activities in front of the computer in a work station composed of a table, chair and elements essential to the execution of the tasks, with the analysis of noise and light inserted in this context.

From the analysis of the case study it was evident that she does not practice sports, can not take at least five minutes to relax, having the whole day filled by activities that vary between work and study.

The collaborator presents pains caused by the tension of the day to day. It was reported that the direct shoulder is very affected, since for the pain scale the number chosen by the collaborator was "5". It presents the same index for "middle back and lower back". The L.E.R. (Repetitive Effort Injuries) and D.O.R.T (Work-Related Musculoskeletal Disorders) disorders are directly linked to the lack of quality in the performance of work, their prevention results in greater productivity, keeping employees happy and consequently avoiding absences and leave, this prevention contributes exponentially to the economy of the company.

It can be noticed that the metallurgical company, regarding the Biomechanical Factors Generators of L.E.R./D.O.R.T is aware of the issues and makes actions for changes in the environment, and in the awareness of employees in relation to posture, food and personal hygiene. It was found that the employee can look for solutions and possibility to include physical activities for prevention and improvement in accordance with the activities performed by her at work.

The employee, when asked about her perceptions of thermal comfort and indoor air quality, reported that the four air conditioning equipment, distributed in the room, offer the necessary comfort, in all seasons of the year, keeping the temperature constant, in the range of 24oc.

14.4 Conclusion

The individual's work cannot be seen only as a daily burden to be fulfilled, because socialization and personal fulfillment are also fundamental parts of a workplace. Logically, the improvement of the performance context is established as a preventive means and acquisition and maintenance of quality of life. It was possible to realize the importance of the practice of Ergonomics within organizations, in order to provide employees with a work with dignified conditions to quietly go through a minimum of eight hours a day, in five days of the week, as is the case of the company and the employee analyzed.

For the company, it is recommended that it not only maintain the current working conditions, but redouble the care with employees, to further increase productivity.

In relation to the employee analyzed throughout the survey, she proposed to re-evaluate her weekly workday in order to provide herself with moments of relaxation and relaxation, avoiding stress and other evils resulting from a busy life in the metalworker's office. It is noticed that the analysis provided the researchers with a greater understanding of the issues related to Ergonomics, regarding the physical, emotional and organizational aspects. In the same way, it was possible to contribute to the company with regard to organizational Ergonomics, informing them about the current laws and the rights of workers.

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II PART

GAME AND GAMIFICATION EXPERIENCE

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15. Game and Gamification for Empowerment and Inclusion

by Alessia Brischetto

Playful activity, despite its importance for humans of all ages, genders and cultural backgrounds, is an aspect of life that is still little explored. In this regard, since the end of the last century, the scientific community has witnessed to the formation of a new discipline, called *Game Studies*. To date, the latter brings together several disciplines, like cognitive sciences, mathematics, pedagogy, computer science and design.

The *Game Studies* have their roots in history and culture since the founding of the society itself. In particular, gaming is a primary attitude and a necessary activity for the generation of the society and its culture (Huizinga, 2002). In a general way, *Game Studies* involve the study of the game mechanics that people exploit for achieving a specific state of affairs.

Let's take into account the definition of game elaborated by the philosopher Suits: "*To play a game is to engage in activity directed towards bringing about a specific state of affairs, using only means permitted by rules, where the rules prohibit more efficient in favour of less efficient means, and where such rules are accepted just because they make possible such activity*" (2014, p.34).

Based on this definition it is worth noting to consider the action of play as a facilitator. Therefore, the game activity turns out to be a useful mean of learning and a way for the creation of experiences. Learning by doing is often unconscious and implies learning notions or behaviors according to an abductive logic and a pragmatic experiential approach (Castells, 2000; Ferri, 2011).

Learning by doing has been increasingly considered as a paradigm, therefore, its role becomes more and more interesting as it embraces existing tools and interdisciplinary methodologies.

Moreover, learning can follow the try and error paradigm that, during a game activity, exploits the features of the game system and leads the player to develop a new attitude towards making mistakes (Bertolo and Mariani, 2013).

Over the years, the modes of game activities have changed, evolving from board games to outdoor games and later, through the advent of technology, up to the birth of videogames. In the last fifty years videogames have redefined the concept of entertainment in our society and its market has become one of the most creative and important in the world, but in many ways it is still a submerged world.

The first video game dates back to 1958 or *Tennis for Two*, made by physicist Higinbotham (1972), followed by the home console *Magnavox*, until gradually arriving at the current generation of consoles represented by *PlayStation 4, Xbox One and Wii U, Nintendo Switch*, and mobile applications and virtual environments (Virtual reality – VR, Augmented Reality – AR) that take advantage of the increased relativity such as *Pokémon Go*.

The evolution of technology and the pervasiveness of video games has allowed people to play a wide range of games. Today, we find video games for children and for the entertainment of adults. Moreover, the birth of social networks, social games and the development of mobile devices, such as smartphones equipped with GPS, connectivity (3G and Wi-Fi) sensors, accelerometers and other technologies, have led to the development of new game dynamics. The user can use the space around him as a gaming environment, thus living unique gaming experiences in real life.

In particular, videogames are a unique medium because of their power over the psychological sphere of man. They can induce the user to play for very long sessions, promote creativity and create relationships between people. On the other hand, their prolonged use can generate serious problems of addiction or alienation.

Another important aspect concerns the ability of video games to generate engagement. Many users, given the massive spread of social media, react differently to engagement than in the past, especially if products do not communicate clearly its objectives. This is forcing companies and institutions to adapt and change their engagement approaches, especially in areas similar to video games. For example, Microsoft has calculated that a new visitor of a website will decide whether or not to stop by in just 10 seconds on average, and the numbers decrease if you consider smartphone traffic.

We have gone from a game design approach based on the analysis of *Function-Focused design* activities and functions, to approaches centered on the *Human-Focused design* for improving the User Experience (Chou, 2019).

These changes have led to a more in-depth study of the dynamics of User Experience and involvement through the development of gamification-based video games.

The main objectives of gamification are to stimulate active and measurable behavior (collecting data based on the actions performed within the game to obtain a profile of the participants, allowing to focus particularly on the target audience, trying to expand the catchment area) and guide an active interest towards the message to be communicated. Implementing game mechanics is one of the most efficient methods to involve people in activities and to facilitate behaviour within a gamified system.

Gamification is aimed at determining player-user behavior[1]. The first real definition of Gamification is by Detering: "*the use of game design elements in non-video game contexts*", where the use is intended in an exclusive way and not as a mere extension. Elements are placed to distinguish the processes and "gamified" (2011) companies from those that use real video games to achieve a purpose. The design distinguishes the technology or other practices adopted in video games from strategies, modes and methods used here. Finally, non-video game contexts outline the specific areas of use, excluding those belonging to the purely video game sphere.

The real novelty and diversification of "gamified" applications and processes, according to this definition, lies in the fact that they are different from a generic "playful" design or from a general playfulness. They lean more towards the world of videogames, with scoring systems, missions, leaderboards and so on. All this leads to generate the same set of emotions in the end user through mechanisms borrowed from the videogame medium.

A second definition following the first, by Huotari and Hamari (2014), highlights its shortcomings. The main criticism to Detering definition is that it adopts only a systematic perspective in his approach. According to these authors, the value of a service is determined solely by the subjective experience of the consumer, as service providers can only make proposals. Thus, the value of a gaming service, whether it is pleasure, suspense, skill or playfulness will always be determined by the individual perception of the player. In other words, it is possible that the use of such a service may lead to gamification experiences for one user but not for another.

The determination of the type of experience is purely individua. The precise definition of gamification by Huotari and Hamari is therefore: "*Gamification refers to a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation*" (2014, p.20).

There are various contexts in which it is possible to apply the gamification method: a site, a community, a service, a content, etc., thus allowing the involvement and participation of users and increase their motivation. In fact, there are several theories about what motivates humans. The Scientific American, an American scientific journal, divides them into three fundamental elements[2]:

- **autonomy:** the user obtains more motivation when he or she is at the head of something and is able, over time, to maintain his or her goals;
- **value:** the user is more motivated when he or she is appreciated while performing an action. If he thinks that a goal is important there is a better chance of completing it;

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- **competence:** the user is stimulated in all the situations and is increasingly committed to giving the best of himself.

In conclusion, gamification is also intended as a mean to effectively convey the various information, as it makes user behavior measurable by collecting data based on the actions performed within the game. Its strong point is the ability to stimulate human instincts, with the aim of creating or satisfying human desires and needs. In fact, a product that uses gamification elements provides, for example, objectives to achieve, levels in which to progress, competition with other users, sharing one's successes and earning rewards.

The fields where gamification is applied are those that today are growing more. Among them the main ones are: products/systems and services, marketing, education, workplace. In particular, in the educational field, gamification generates different and more stimulating teaching logics, and in some cases, yields immersive dynamics, as well as the personalization of learning styles through collaborative behaviors. This can be achieved through the use of different levels of playfulness. The first and simplest way is through a different conception of the didactic experience. For instance, it is enough to change the evaluation method from the standard one to the one that assigns points for each task carried out. This will then contribute to create the final grade, or to give the possibility to students who stand out, to earn badges or achievements, or to stimulate collaborative learning actions (Baek and Touati, 2020). In the most advanced method we use a real game connected to the field of application of the subject. Afterwars, we analyze the starting statistics of the player by refining the difficulty and the experiences that will be met. From the statistics you get a skills tree, a collection of strengths and weaknesses of the user, which will show objectives to improve and areas where you are above average. This output will be used to connect with your classmates or course, as allies or rivals, and to receive missions customized according to your level of difficulty.

The broad forecasts of growth in the gamification market have rapidly gained the international and European interest. In recent years, the EU community is trying to include this as much as possible in research and projects.

An exemplary case is represented by 2013 study on the potential of digital games for the empowerment and social inclusion of groups at risk of social and economic exclusion, which was developed within the program of the *Digital Games for Empowerment and Inclusion – DGEI*. This study estimated that 10 million people in Europe are at risk of social exclusion. This poses society and businesses with a challenge and with the need of tackling important issues, like innovation, unemployment, discrimination, social barriers and poverty factors.

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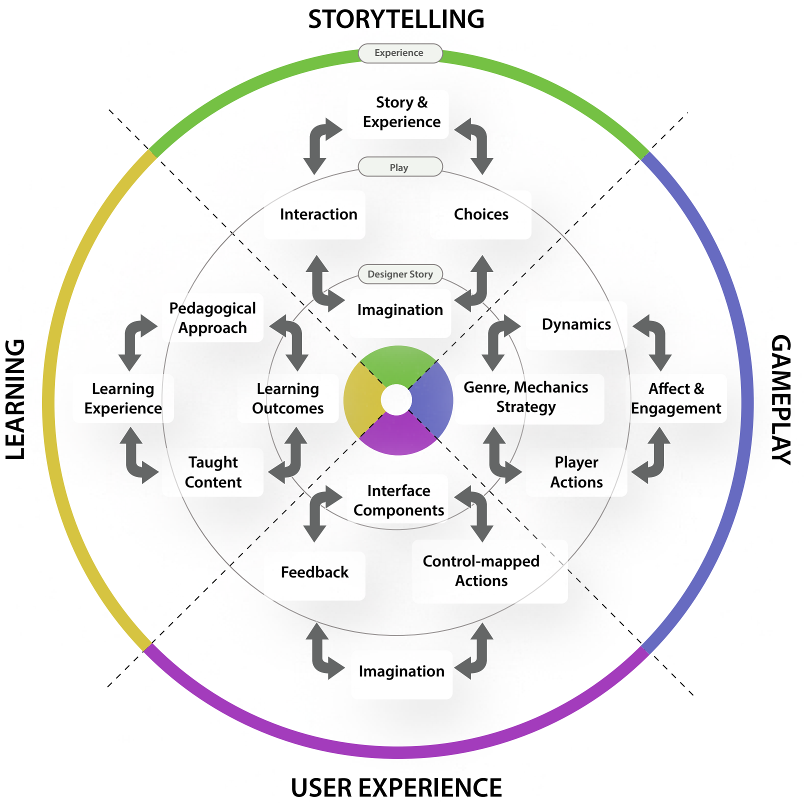

Fig. 15.1 - Serious games methodology

The birth of this research is due to the growing use, in recent years, of video games for work activities and of Gamification as a key component for social innovation. It has emerged that the use of video games to combat empowerment and social inclusion is part of a larger trend that has been growing for the past 10 years through the inclusion of video games techniques and technologies in areas of non-gaming activities, such as health, education, defence or communication. The games that are outside the traditional game production sector are properly related to the research and development sectors of Gamification or serious games[3] (Fig. 15.1). Flanagan, in the book Critical Play-radical game design (2009), talking about serious games, argues that the gaming experience must have the right balance between fun and teaching, because a game too much based on entertainment could be superficial and of little importance. On the contrary, a game too much based on learning could be boring and without appeal in a short time.

Games are classified by genre or game mechanics, such as shooter, adventure, sports, driving games, horror, puzzles and simulations (Despain, 2005; Lindley 2003). Another class is for educational purposes (Sawyer and Smith, 2008; Albrich, 2009). With respect to learning objectives, the most comprehensive is Bloom's taxonomy (1958). Bloom's Taxonomy is a classification of different levels of cognitive learning objectives that educators set for students. These "learning objectives" in the Taxonomy describe six progressive levels of learning, from the foundation to the pinnacle: knowledge, comprehension, application, analysis, synthesis, and evaluation (Buchanan, Wolanczyk and Zinghini, 2011).

Serious games can be applied in different fields, as they represent a flexible and useful way of teaching for potentially complete preparation and education in any field, even if there are various degrees of difficulty. Michael and Chen provide in their essay "*Serious games-games that educate, train and inform*" (2005), an analysis of the most relevant areas in which serious games are used.

1. Within the field of health, very widespread and useful both for those suffering from diseases and for those who want to improve their lifestyle. Three sub-categories belong to this area:
   - games for doctors to train and instruct medical staff. Some examples of games are: Auscultation, Pulse!, ACLS Interactive, The Cave etc.;
   - games for patients during the practice of the distraction therapy. Thanks to these games, patients shift their attention to pain to other sources of interest, trying to propose exciting and engaging activities, especially concerning the sensory perception of the playing patient. Some examples of games are: Packie and Marlon, Glucoboy, Watch, discover, think and act, Full Spectrum Warrior etc.;
   - games for the world of fitness, to improve and develop all motor practices. Some examples of games are: Wii fit, Dance Revolution etc..
2. Within the field of training. These types of games still today struggle to enter the school system, because they are sometimes wrongly considered useless, even though they promote learning and are an excellent aid for teaching.
3. Within the corporate sphere, with games that encourage learning, practice or updating of various factors, in order to better educate the staff of a company/studio. Some examples of games are: *Objection!, Darwin: survival of the fittest etc*..
4. Governmental scope, with games that somehow allow to inform, analyze and in some cases solve problems related to human rights, poverty, global and political conflicts. Some examples of games are: *Angel five, Incident Commander, Quandaries, Port of Rottherdam Incident, Confi-*

gurator and Fire Brigade Commander Training, Dynamic Tsunami Hazard Map, Darfur Is Dying, September 12th, Molleindustria, Oiligharchy, Leaky World ect..

5. Military field, one of the first to be interested in games with strategic simulation or simulation of vehicle features such as flight simulators. Some examples of games are: *Vector, Tactical Iraqui, Unreal tournament, etc.*.

Other fields of application of serious games and gamification are for example business planning and activism. In the first area they help to make decisions among many interested people or to teach professionals how to work in difficult environments. The second one is represented by games that are often free of charge and have the sole objective of getting a message to as many people as possible; or they are developed by public or private bodies and aim to reduce personal consumption, such as *oPower*, whose platform is adopted by over 90 electricity companies worldwide. By registering for the service, you can access an app that, starting from the analysis of your consumption, starts to draw up electrical virtuosity rankings. At any time, you can know how much you are consuming and in what relationship with your relatives or friends, so to create a beneficial competition. All this is supported by suggestions on energy saving and by the presence of groups which facilitate collaborative work and the achievement of collective goals. In the scientific field they are used to facilitate education and communication. For instance, Foldit allows to convince the public to support and help a common cause.

Although culture represents the smallest percentage among the sectors influenced by Gamification, significant developments are expected, particularly in the areas of cultural heritage and tourism. Precisely, in areas where the classical media have been able to play an important role, education through these new methods plays an equally vital role and the potential audience is enormous. For example, the video game *Assassin's Creed* and its sequel, *Brotherhood*, are two games, respectively from 2009 and 2010, by the producer Ubisoft.

The game, set during the Renaissance in many Italian cities, including Venice, Rome, Florence and Forlì, received a huge commercial and critical success, selling over 18 million copies worldwide and winning numerous awards. Most important, it has given millions of people the chance to know and visit places recreated in detail by art experts and historians, such as Palazzo Strozzi, the Colosseum or the bell tower of San Marco. Peculiar is the case of the small town of Monteriggioni in Tuscany, where one of the key levels of the game is set in. This fact produced an increase of 16% for tourist overnight stays and 30% for visits to its museums and historical walls. A research conducted by the municipality in 2016, states that about 16% of tourists have known the village through Assassin's Creed, despite the fact that 7 years had already passed since its release on the gaming market.

Digital gaming is also attracting a lot of interest in the area of professional training, which was already interested from many time to e-learning. It is estimated that 1% of the 52 billion euros spent in Europe is earmarked for this purpose.

Today, within the evolutionary path concerning learning processes, serious games are considered a real cultural revolution. Thanks to their ability to simulate different aspects of the experience, they are powerful and perfect tools for the acquisition and enhancement of different skills in multiple areas. The learning process that passes through serious games is therefore able to integrate declarative and procedural knowledge (Anolli and Mantovani, 2011). However, what makes serious games effective and powerful in learning is the presence of three dimensions.

- **Simulative dimension:** allows the user to get in touch with knowledge through his senses, his body, and not only on an abstract level. In fact, with the use of digital devices that support serious games, users can reproduce aspects present in the real experience and anticipate future perspectives, always keeping an active role.
- **Ludic dimension:** refers to the motivational and user involvement elements. The same mechanics that make video games so attractive and engaging (e.g. the use of scores, missions, competition systems), are able to motivate the user in the development of serious games and in the training process, especially in the long term. Moreover, the playful aspects allow the user to live a rewarding experience, a source of positive emotions such as interest, curiosity, exploration, sense of challenge and self-efficacy. These positive emotions have a strong influence on both attention and memorization skills.
- **Formative dimension:** you mainly refer to the integration of information and knowledge, whose learning is the main objective.

As regards the level of contents, serious games allow for learning of different knowledge, such as medieval history, mathematics or astronomical sciences, but also the learning of procedural knowledge related to various fields, such as surgery, finance, etc. Moreover, serious games are also very effective as tools for the enhancement of some transversal skills, such as leadership, decision making or basic communication skills.

It is therefore clear that serious games allow achieving different learning objectives and not the goal, as it happens for simple video games. Serious games in Europe are mainly applied in the fields of defence, education and culture, training and recruitment, information, communications and health.

Education is one of the sectors where, at European level, Gamification has come first. In fact, any textbook, from primary school to high school, is obliged to have an online component and many of them have already introduced playful elements within them. Together this, there is the growing market of e-learning (Acquah and Katz, 2020).

European research concludes that although the market for serious games and gamification is still young and immature, its already wide diffusion and adoption by a multitude of sectors can only lead to expansion in the coming years.

The *European Horizon 2020* program itself, contains over 100 studies on the application, applicability or literature concerning Gamification, but the most developed is Gaming Horizons[4], coordinated by the UK and with the participation of the CNR (National Research Council).

Gaming Horizons is a project whose aim is to examine gaming and gamification as real research areas at European level, adopting a multidisciplinary perspective based on the integration of social sciences and humanities. It focuses mainly on the use of video games for learning and cultural development purposes. This has been achieved thanks to the fruitful collaboration between communities of developers, policy makers, users and researchers. Within the project, a methodology of analysis based on consultation and data collection through the involvement of experts, gamified learning issues, interviews, events and seminars was adopted.

The first results of the survey were from the literature point of view together with the identification of the most relevant issues. Among the latter, the negative contribution of videogames on people's lives, especially the violence in games and aggressive behaviors by players, were the most investigated issues. Due to the increasing separation of videogames from their stereotyped roots regarding characters and stories, there are positive developments in the areas of gender representation and social inclusion.

The European Union makes a clear distinction between the "serious" or "applied" games sector and the traditional entertainment sector and invests only in the former, due to the fact that video game development is seen in terms of engineering, while the social application of games and gamification provide more easily measurable benefits (Persico *et. al.*, 2017). Stakeholders in this type of projects, however, are always doubtful about the actual ability of gamified methodologies to achieve specific and measurable impacts in social and educational sectors. There is the idea that the engagement created between the player and the videogame alone hardly creates productive outlets, unless it intersects with other environments.

Literature research focused on the psychological component has highlighted both the strengths and weaknesses of the impact of "serious games" on peo-

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ple's lives. Dependence, cognitive benefits, motivation and engagement have been among the most researched topics in this field (Wronowski *et.al.*, 2020).

The project ends with a series of tips to improve and encourage the spread and application of gaming in various sectors. One of the biggest difficulties to overcome is considered the lack of propensity by teachers to expand and revolutionize their teaching methods and in general their extraneousness to videogame concepts. It should also be considered the difficulty of creating a game that is attractive and understandable to all.

Currently, international research is engaged in the development of methodologies and strategies to implement this area of research and to identify new research perspectives. In Europe there are many projects that are investigating the role of gamification and serious games in different areas of research. Of relevance, within the social inclusion sector, the project PUDCAD: Practicing Universal Design Principles In Design Education Through A Cad-Based Game funded by the ERASMUS+ KA203 2017 program. The main aim of the project is the development of a CAD-based platform that will allow students to learn the basic and advanced principles of Universal Design through game dynamics stimulating Universal Design.

Within the present framework, research and experiments carried out in recent years have shown that the Design discipline sector, including Ergonomics for Design, Interaction Design, etc., thanks to its methodologies, plays a strategic role and development prospects are numerous. This led to the development of research centers and to introduce specific teachings on Game Design within the university training courses. Game Design is a new discipline destined to grow and generate more and more dynamic and innovative knowledge and approaches over time.

Notes

[1] In the rhetoric that supports gamification there shines a vision of the game that is strongly reward oriented, that is, reward in terms of rewards and objectives. Undoubtedly there are case studies that support this approach also in traditional game design (i.e. not Social Games, Massive Multiplayer Online Games (MMOG), or Advergame): think, as a typical case study, PopCap's Peggle that basically makes gratification the main activity of the game.

[2] These points help to understand how gamification techniques are conveyed in people's innate emotions. In the review published by Ryan and Deci (2000) – *"Intrinsic and extrinsic motivations: Classic definitions and new directions" Contemporary educational psychology* 25, 1: 54-67 – the author divides these motivations into extrinsic and intrinsic motivation.

[3] Serious games are digital games that do not have exclusively or primarily an entertainment purpose, but contain educational elements. Generally serious games are educational tools and ideally the serious and playful aspects are in balance. At the center of attention is the desire to create an effective and enjoyable educational experience, while the genre, technology, support and audience varies. In practice, unlike Gamification where we find mechanics borrowed from video games but still within platforms and experience that clearly are not, a serious game is a real game but designed with a specific purpose, other than mere entertainment.

[4] For more information on the Gaminghorizons project please visit the following links: www.gaminghorizons.eu.

[5] For more information visit www.pudcad.itu.edu.tr/en or https://euraxess.ec.europa.eu/jobs/276416.

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16. Tiles and Patterns. Modular Concept in PUDCAD Learning Game Scenario

by Giorgio Buratti, Fiammetta Costa, Michela Rossi

Abstract

PUDCAD is a project involving several European university institutes, supported by the European Erasmus + Program, that promotes specific skills acquisition and the improvement of students and young workers preparation levels to increase their ability to operate in UE. By developing a ludic application, configured not only as a tool for digital drawing but as a real learning software, PUDCAD intends to educate university Design students about Universal Design, an ergonomic approach that provides for the use of environments and products regardless of age, social conditions and user's physical skills.

The Politecnico di Milano team conducted a research in secondary schools, evolving a modular process capable of implementing precise features. The use of a module (from the Latin modus, "measure") in any design activity involves the definition of a basic unit assigned by the designer, from which all parts of a complex descend by multiplication or division. The same module can be developed in different patterns, but regardless of the formal result, purpose of the composition rules is to support and order the parts in a coordinated whole. Similarly the game, an occupation that usually suggests nice and apparently disordered conditions, is an activity always regulated by internal principles, perhaps not always responding to rational needs, but essential to establish an order that involves the end of the playful principle if violated.

In the same way, the PUDCAD application development of game environments is based on a pattern aimed at spreading the principles of Universal Design and in acquiring appropriate design practices. This paper illustrates the methodological path and the conceptual tools adopted in the interactive game development.

Keywords: *Gamification, Universal Design, Inclusion, Game Pattern.*

16.1 Introduction

Designing a digital application requires a method that allows to document, to evaluate and to plane choices. At dawn of videogame design, in the late Sixties, game-designers as well as using inspiration necessary in a brand new sector, deepened the mechanics of board games and other existing entertaining activities. In implementing this new digital products were also borrowed traditional media' narrative tools and techniques such as cinematography, television and scripting.

The real computer-based programs construction also made necessary the formal rigor of mathematics, not only in algorithms writing, the computer system engine, but also in creating schemes that allow a logic and consistency with human.

The first applications benefited from Games Theory researches, discipline of mathematics whose main purpose is to analyze conflictual situations, starting from the assumption that a final outcome of a dispute depends on choices made by contenders and therefore seeking cooperative and competitive solutions by studying individual decisions.

The exponential success of sales and distribution that occurred over the next fifty years determined the intrinsic difficulty in framing video-game in a theoretical context. As often happens with a new media introduction, the exaltation for the available possibilities, not least economic reasons, produced a proliferation of products without at the same time developing a real definition lexicon or establishing disciplinary boundaries. This is also due to the intrinsic nature of the video game, which has unique features.

Despite the historical link with previous entertainment media, a video game cannot be considered as a simple film or interactive novel. A video game does not tell a story, but it's the player who tells and creates it through his/her performances[1]. In a painting, a song, a film or a book, the user cannot change the outcome or act actively on the artwork, while the video-gamer modifies the result with his/her actions, since he/she is simultaneously a spectator and an actor. "The idea of including the viewer in a representation, introducing him to experiment an experience that transcends real world, is prerogative of all artistic manifestations since the dawn of humankind [...] however it's only with the advent of computer that this effect has achieved the most significant outcomes, allowing user "physical" inclusion with the ability to interact with images"[2].

In the new digital device the possible answers to the same situation are ideally endless, and it is through the player actions that these possibilities materialize in a sequence of events and precise activities that determine the gaming experience.As extended the possible variables must be connected by internal

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principles, essential to establish an order that if violated involves the end of the playful principle.

The construction of game environment is therefore not a single aesthetic choice, but a formal representation of the system of rules. The definition of PUDCAD's interaction space instantiates a process capable of guiding the user in knowing and attributing the correct meaning to the signs by a feedback systems related to interaction between the players and the game itself.

16.2 Edutainment, Gamification and Learning

Considering the playful artifact as a coherent project and starting research in this field it's a fairly recent practice. For just over a decade, since video games have established themselves as one of the most pervasive communication media, the need to investigate related themes has been highlighted.

New theory related to different scientific branches and new definitions have appeared. Edutainment[3] for example, a term derived from publishing, recognizes the ability to produce meaningful experiences in playful forms of communication. Gamification[4], on the other hand, is a term closer to the digital media industry, which approximately proposes the same concepts placing emphasis on the practice of game. Although there is no a single definition yet, but a related concepts stratification, the most used definition in academic world means by gamification the transfer of playful dynamics to activities that do not directly deal with game[5]. A significant number of authors also tend to the definition Serious Game or Applied Games if the primary purpose is not pure entertainment, but an educational or training goal. Regardless of the nomenclature, the general objective of these systems is to convey information, favoring the active interest of users in order to increase their knowledge, skills or change their behavior. Although the term gamification has a broader meaning than video games, it is through the video game forms that the link between learning and technology is made explicit. Personalization and speed of the message promote a more efficient active participation because by dynamic behaviors implementation meanings connect to an action supporting experiential learning[6].

16.3 Implementation of Game Environment

We have already described how the design of PUDCAD ludic application followed a very specific procedural flow which considered fundamental parameters such as game mechanics, dynamics, targets and resources[7].

Definition of the game environment is part of mechanics implementation, the category that includes actions and processes used to create the basis of entire application logical structure. In other words what establishes the constraints and limits summarized in the term "game pattern".

The game pattern is a procedure based on the rules that define the playful activity and that, starting from a common root, can be developed in a multiplicity of declinations and variants that can be traced back to the initial scheme. For example, in the classic game Chutes and Ladders the winner is the first player who arrive with his own marker at the end of a path, while in Monopoly is essential to be the first to build constructions in specific spaces. In both cases, the game pattern is to achieve a specific goal first, a purpose that can be traced back to the archetypal game of run, played in early childhood.

In the case of PUDCAD the components of immersiveness and interactivity should expand and enhance the learning experience, by an "*immersion in a simulated world regulated by technical laws in which the active user's actions are theologically oriented*"[8]. Here we enter in the peculiar video games paradigm, the only playful activity that does not require to learn the rules beforehand. In fact, the player only discovers by trial and error what he has to do and, as the simulation progresses, he comes to understand the goal and decode the game rules. The game space is investigated and the information code creates the constraints, guiding the learning user by studying what the game allows to do and how it responds to inputs. There is therefore a significant playful essence in which representation part coincides with different functional and organizational levels, able to enhance and transmit significant symbolic contents. As underlined by Huiziga:

"*All play moves and has its being within a playground marked off beforehand either materially or ideally, deliberately or as a matter of course. […] The arena, the card-table, the magic circle, the temple, the stage, the screen, the tennis court, the court of justice, etc., are all in form and function play-grounds, i.e. forbidden spots, isolated, hedged round, hallowed, within which special rules obtain. All are temporary worlds within the ordinary world, dedicated to the performance of an act apart*"[9].

Within this space it is necessary for the players to be provided with a shared linguistic sign context, designed so that the player receives information with a simple glance. PUDCAD is an application that involves the design of a school environment, through the identification of some Inclusive Design fundamental parameters that will be the basis of game mechanics. The semantic system was tested in a didactic experience that simulated the PUDCAD digital application.

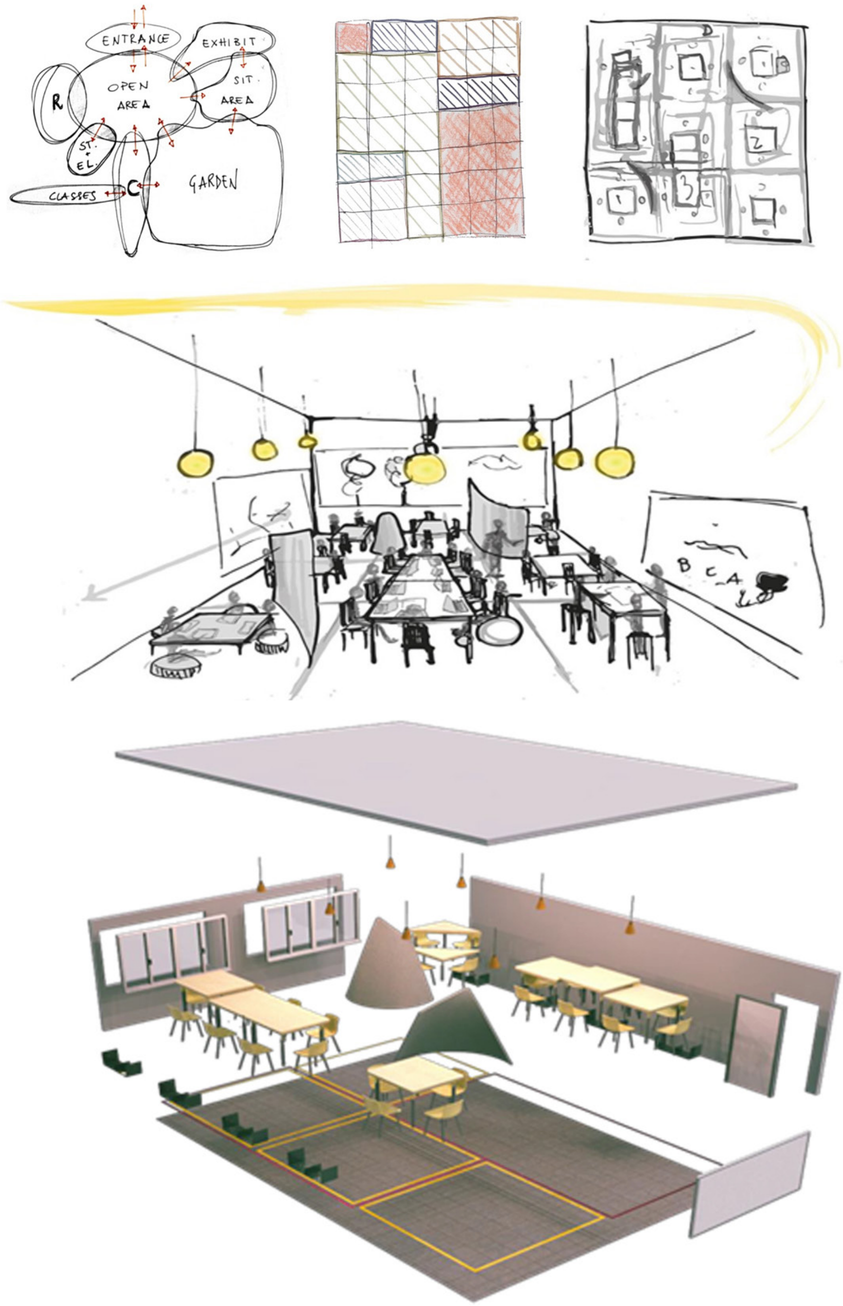

Fig. 16.1 - From the concept to the gaming environment. Design development of an educational classroom starting from the modular grid

Students had to design modular school spaces, based on construction and furnishing elements composition with standardized dimensions, established on multiples and sub-multiples of a design grid basic module (Fig. 16.1). Each student work-team has therefore developed its own set of elements that can be inserted into a modular grid of side 3m, which defines the standard surfaces of different environments, organized around a common distribution space.

The next task was to individually recompose the different school space functions in order to optimize the environments usability for the school population, consisting of students and teaching and support staff.

The modular logic of school buildings composition and the application of the BIM[10] model construction logic offers the conceptual reference for the game definition.

The modular grid becomes the pattern of a board similar to that of Scrabble and the constructive elements are the cards available to the players/designers, which can be combined according to logical and/or quantitative rules, in a similar way to what happens with Domino tiles.

A set of scores and game mechanics will provide information on the spatial organization's adherence to the principles of Universal Design, while increasing levels of difficulty may be connected to greater complexity in the space articulation of modular building.

The game could develop by the modelling of the school in the digital space, room after room, over a pattern grid that rules the building growth, without any prefixed goal, but the maximum score of the winner team. In this case the game cards are the elements that build each room (classrooms, canteen, laboratories, library, entrance hall…).

Different building tiles should have different values, with several generic cards, some special cards, and may be a Joker. The square module is a basic concept in design and in table games: modular patterns on regular grids are a common and recurring feature both in games and in building design. It is furthermore implicit in school architecture that is always a modular building because of the repetitive layout of classrooms (Fig. 16.2). Otherwise players can move with dice into the digital space, which is ruled by the same pattern of the building, discovering the school and living the architecture with the limitation of a physical disability they draw lots with cards or they find on their path. The game scenario is anyway a school with classrooms and other special spaces, built on a regular lattice that rule each play action:

- modular building tiles allow the (partially) random combination elements in always different architectures;
- modular grid of the game pattern rules the building and the players action inside the school.

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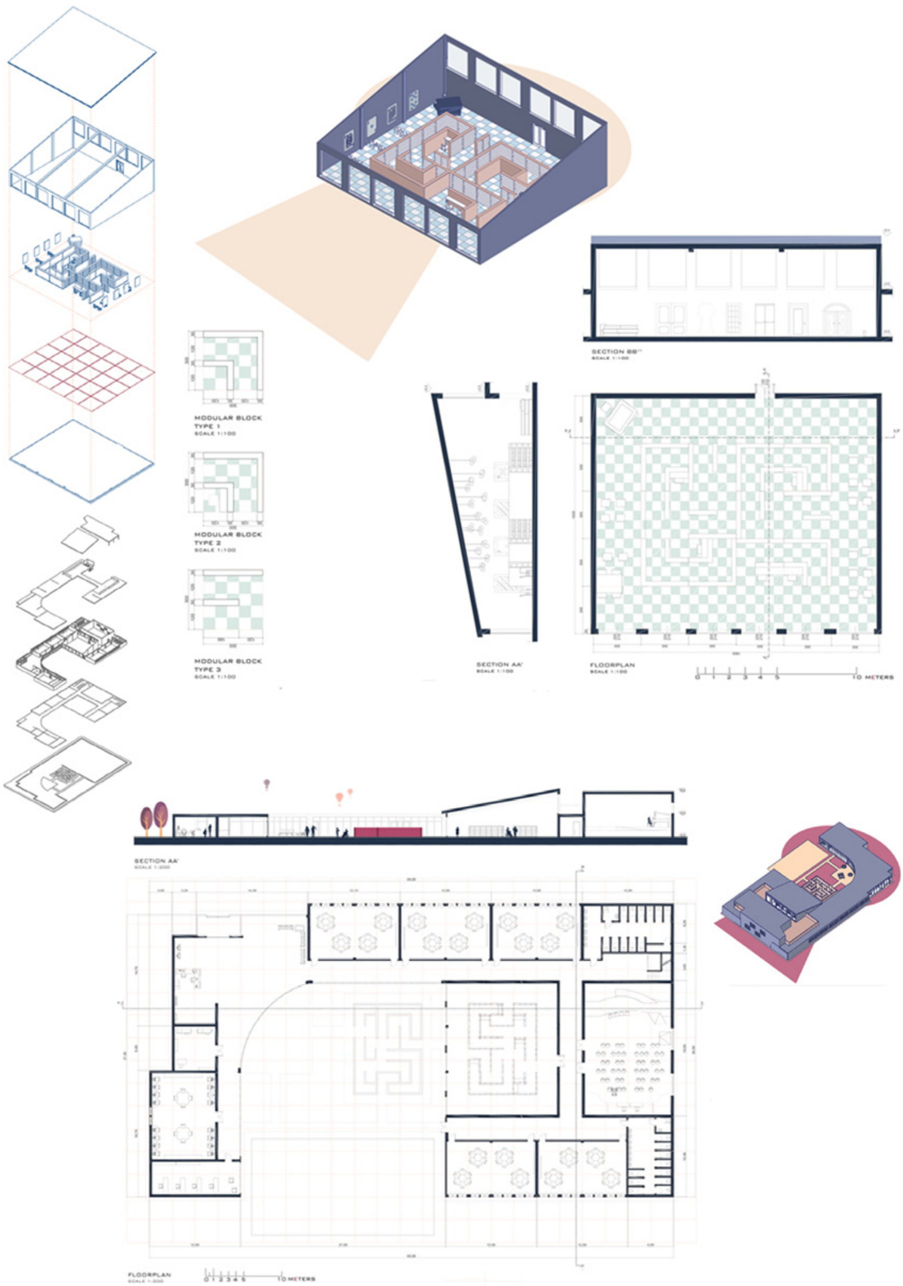

Fig. 16.2 - One of the patterns properties is that the multiplicity that distinguishes them can be distributed on different levels, each one characterized by different behavior. In this case the square module rules the furniture, the classroom space and the whole school environment

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16.4 Conclusion

The experimented modular design approach, integrated with different research units results, will be the input for the last step of the PUDCAD project: the final game realization. However, the development and sharing of experiences and knowledge among the various research groups allows some considerations to be made. The relationship between gamification and teaching opens up new experiences where learning is not based on the ability to remember and repeat information, but on the capacity to find information, evaluate and use it coherently in the right context. Teachers have the possibility to incorporate didactic notions in a narrative context, start the learning process by providing a problem for the participant starting from an elementary level to a progressively more difficult tasks and finally evaluating the expected results

Using of pattern is as a methodological instrument able at creating structure and coherence between the various aspects of game design and overseeing its various levels. Modular patterns create and configure relations between entities, they are abstract representations that identify the organisation and qualitative aspect of a game structure, enabling its realisation and recognition. In the final analysis, it is possible to assert that patterns are the configuration of the relations between the components of the ludic application, which determine its essential characteristics. The revolution inherent design of ludic digital tools is the way they transformed design discipline from iconic representation to the representation of relations and processes. Far too many people still consider the video game as a simple commodity or a form of entertainment, while it would be necessary to understand that it's a cultural artifact endowed with recognizable linguistic, iconographic and thematic codes, whose potential is still to be investigated.

In this paper Giorgio Buratti has dealt with gamification processes in defining the game space; Michela Rossi analyzed the relationship between modularity and game environment and Fiammetta Costa defined Universal Design standard for the school environment.

Notes

[1] De Koven B.D, *Fun is Fine, Toward a Philosophy of Game Design*, on www.finegamedesign.com.

[2] Bittanti M. (2002), *Per una cultura dei videogames: Teorie e prassi del video giocare,* Edizioni Unicopli, Milano. Translations made by the authors.

[3] Combination of educational and entertainment. Neologism coined by Bob Heyman while producing documenta-

ries for National Geographic. The term was initially used to indicate the forms of playful communication aimed at teaching. The concept has been extended to all that can be communicated, thanks to a game, in a nice and productive way.

[4] The term was proposed by the English game programmer Nick Pelling in 2002 and has acquired relative autonomy since 2010.

[5] Desmet A., Van Ryckeghem D., Compernolle S., Baranowski T.,Thompson D., Crombez G., Poels K.,Van Lippevelde W., Bastiaensens S.,Van Cleemput K., Vandebosch H., De Bourdeaudhuij I., Hospital G., Street T., Gard T., Hoge E.A., Kerr C. (2014), "A meta-analysis of serious digital games", *Preventive Medicine*, Baltim, 69: 95-107.

[6] Felicia P. (2011), *What evidence is there that digital games can be better than traditional methods to motivate and teach students?* Waterford Institute of Technology. https://pdfs.semanticscholar.org.

[7] Buratti G.,Costa F., Rossi M. (2019), *Gamifications meets BIM. PUDCAD: advances in development of a games to teach universal design principles.* in Empler T., Fusinetti A., edited by, *3D Modeling and BIM. Modelli E Soluzioni Per La Digitalizzazione*. ISBN:9788849619423.

[8] Accordi R.M. (2014), *Storia del videogioco: Dagli anni Cinquanta a oggi*, Carocci, Roma (p. 7). Translations made by the authors.

[9] Huizinga J. (1949), *Homo Ludens. A Study Of The Play-Element In Culture, Routledge and Kegan Paul*, Boston And Henley, London (p. 10).

[10] Building information modeling (BIM) is a process supported by various tools and technologies involving the generation and management of digital representations of physical and functional characteristics of places. Using an integrate 3D model-based process it's possible to give architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure.

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17. Interrelations Between Technology, Interface and Experience Design Decisions

by Guven Catak, Çetin Tüker

Abstract

In this study we conducted two case studies focusing on how interface, workflow, Ergonomics and User Experience alters when a software migrates from its native hardware platform to a new hardware mostly forced by a new emerging technology. In the domain of this study, these hardware platforms are; (a) personal computers equipped with two dimensional monitors and using the interaction method of WIMP (windows, icons, mouse pointer); (b) touch screen mobile devices, equipped with touch sensitive hardware interfaces and two dimensional display technologies; (c) immersive virtual reality (IVR) systems equipped with head mounted displays with three dimensional, stereoscopic display technologies Examples of software to be examined are; (a) two dimensional photo editing and sketching tools; (b) three dimensional modeling tools which were migrated from their native hardware platform to other platforms were selected.

For all cases we observed cross platform adaptations which includes redesigning of the interface, interaction, User Experience (UX) to fit in the needs, abilities, potentials, and predictions of the new platform. Mostly this phenomenon is more than just adapting the software as it is existed in its native platform to the new platform because new technologies make it impossible to the user to interact with the system by using the original interface so designers forced to redesign the software from scratch to fit in the needs and possibilities of the new platform.

In this study we aim to explore how technology, interface and UX/UI Design decisions affect each other and how new technologies change our understanding of interaction and User Experience.

Keywords: *Ergonomics, Cross platform redesign, Adaptation, Interface Design, UX Design.*

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17.1 Introduction

New hardware platforms are being introduced and penetrating in our lives every year. Several types of Personal Computers have been introduced since 1980's and starting from the first decade of the 21st century, mobile phones and tablet computers spread widely. All these new hardware require a new type of interaction method, user interface and therefore User Experience. As processor prizes are going down more rapidly, VR / XR systems are coming out of the research laboratories and being penetrated into our daily lives.

As software and gaming companies start facing these rapid changes, they decide to migrate their prominent software products to new hardware platforms. But as interface technologies, use cases and interaction methods are different in these new hardware platforms, the success of Usability and User Experience of the ported software product is open to questioning.

So we decided to carry out a series of studies to understand the theoretical framework of how; interface, workflow, Ergonomics and User Experience changes when a software migrates from its native hardware platform to a new hardware platform.

As an hypothesis, when a video game or a software designed for it's native platform migrates to a new platform and if it tries to mimic the native software, the ported software will not fit into the the new platform and it will lose it's functionality, usability, emotional contact satisfaction at a certain level.

17.2 Background

Fang, Chen and Huang (2016) carried out a research with Monopoly and Jenga games. Originally these games are physical board games. Desktop PC and tablet versions of these games are also exist. Fang *et al.* (2016) compared satisfaction levels of gamers while playing these different versions in three design levels which are Visceral, behavioral and reflective. They used a questionaire in likert scale which includes 15 questions. Native platform in which the original game was designed for, is significantly successfull than the ported platforms.

This shows, at least for these two games, simply porting the game to a new platform by keeping the game mechanics and story is not enough to create a successful gameplay in the migrated platform, though in best case it can be possible for players to play the game but the player will not feel the same level of satisfaction. Therefore we can not make a generelization that porting to new platforms works well.

Tuker (2018, p. 4) defines a phenomenon for video games named as cross platform redesign which means "*[...] crossplatform adaptations and new interfaces to redesign the interface, interaction, user experience (UX), game mechanics, rules, assets, and even the narrative and genre of a game which already existed in its native platform, to fit in the needs, abilities, potentials, and predictions of the new (ported or migrated) platform*". Crossplatform redesign is needed because a game which was designed for the native platforms interaction technology creates its own User Experience and fits in the native platform but the change of the platform causes a change on the User Experience and this changes the satisfaction level of the player. Sometimes the interaction technology of the original platform and ported platform are so different that the game can become impossible to play. Therefore designers change the UX, UI, game genre, game mechanics and even sometimes the story of the video game.

Tuker (2018) demonstrates the idea on Tetris and GTA video games comparing the native versions of these games with their migrated versions. Grand Theft Auto is a well known video game which natively runs on PC platform. It is a third person perspective video game with an open world free roaming design, which means player views the player character and non-player characters like an observer and can roam around the environment freely without any necessity to strictly follow the game missions. Original interaction controls of GTA is WASD keys for moving forwardi back, left and right and mouse pointer to look around ans shooting. After mobile platforms became popular as gaming platforms, GTA is ported to mobile platforms with touch screen interface. Tetris, the last case of the Tuker's (2018) study, is a popular video game developed by Russian designers in 1990's inspired from pentaminoes board game and ported to several hardware platforms.

17.3 Method

We conducted 2 case studies, on six photo editing and illustration software, and three design software, to examine how UX, UI, functionality (for design software) changes when they were ported to a new hardware platform. Selected design software are SketchUp (Trimble) for PC platform, FormIt (Autodesk) for mobile touch screen platform and VR Sketch (Trimble) for IVR platform. Selected photo editors and illustration software are Photoshop (Adobe) for PC platform, PhotoShop Fix, PhotoShop Mix and PhotoShop Express for mobile touch screen platform, and TiltBrush (Google) and GravitySketch for IVR platform.

SketchUp is a very popular, easy to learn, three dimensional modeling software which runs on PC platform with standard flat screen video displays with WIMP (Windows, icons, mouse pointer) interface. FormIt, is another popular three dimensional modeling tool which can run on PC and tablet platforms. It has many other features other than it's modeling capabilities which are not a part of this case study. Beyond these features, the modeling technique FormIt uses to create three dimensional models is almost similar with SketchUp. Both creates a two dimensional line based outline and uses a tool called "push-pull" to extrude the two dimensional outline and create three dimensional models. FormIt is included in this study because it runs on tablet platform which interacts with user with hand gestures on a flat touchscreen or a specially designed stylus. VR Sketch is a modeling tool which uses the same technique, "push-pull" in an immersive virtual reality (IVR) environment. In IVR it is not possible to use WIMP paradigm. Therefore, modeling tools developed for using in IVR mostly uses three dimensional icons which is carried by or attached to either of the two hand controllers. User activates the three dimensional tool set or icon menu by pulling the trigger on either of the hand controllers and select the icon with the other hand controller from the activated menu panel.

PhotoShop (Adobe) is a popular photo editing software which runs on PC platform natively with standard flat screen displays with WIMP interface. Photoshop Express, Photoshop Fix and Photoshop Mix are the applications designed for mobile envitonment. As Photoshop for PC is a very large software which is capable of many types of photo editing, color correction, illustration and painting, for mobile devices it has been divided into several applications focused on a special need. Photoshop Sketche is a mobile application dedicated to create illustrations. All these software have the capability to edit or create images on a pixel based two dimensional surface. TiltBrush (Google) and GravitySketch are illustration tools developed for IVR environment and capable of creating three dimensional line based illustrations without any pixel based photo editing capabilities.

For the case studies we identified four parameters; (a) interaction technology; (b) precision; (c) usability; (d) ergonomy, to analyze how UX, UI and workflow changes depending on the three hardware platforms (or environments) as; (a) PC with two dimensional flat screen and WIMP Interface Design; (b) mobile devices with two dimensional flat screen and touchscreen interface; (c) IVR with several interface and Interaction Designs (Tab. 1.1).

As this is an exploratory study to explore and understand the possible factors and parameters of how hardware and interaction technology developments affect software design, we did not chose to define any independent and dependent variables. As the method, we observed and identified the changes, similarities and evolving factors in the functional software workflow as the hardware and interaction technology changes. For further follow up qualitative and quantitative studies must be conducted to measure weights of these factors in detail.

Tab. 17.1 - Software and platforms selected to be analyzed for the case studies

	PC WIMP	Mobile Touchscreen	IVR
2D Photo Editing and Illustration	PhotoShop	PhotoShop Mix PhotoShop Fix Photoshop Express Photoshop Sketch	TiltBrush GravitySketch
3D Modeling	SketchUp	FormIt	VR Sketch

17.4 Results

17.4.1 2D Photo Editing, Freehand Sketching and Illustration Software

Photoshop is a very large photo editing, freehand sketching and illustration software. Photoshop was natively designed for Apple Macintosh exclusively and released in 1990. Interaction Design of photoshop is based on WIMP interface and screen size and resolution is adaptive to any size and resolution supported by the operating system. Users can manipulate down to a single pixel detail by choosing necessary commands from the menus distributed around the large work area. As PC systems designed to be placed on a table top and users to be seated in fron of the system, it is possible to work with photoshop for many hours and it is relatively easy to work on smallest details.

Although native Photosop was designed for mouse pointer, it is not very easy to create freeform curves and sketches with it. When tablets (without a screen) developed, users adopted this new technology but still they were drawing on a tablet with a special stylus while looking on a screen placed far away from the drawing area. PC platforms benefit from the development of touchscreens and users started using photoshop as a digital paper surface by sketching on the screen supported with pressure-sensitivity giving the possibility to sketch lines with varying weights (Tab. 17.2).

When mobile platforms become popular, designers of PhotoShop decided to create mobile versions of PhotoShop editor for mobile devices. Biggest challenges for this new hardware platform are lack of keyboard and mouse pointers, small screen size and functional needs that a different type of users (other than professional designers) that PhotoShop has to satisfy. To achieve the desired functionality, instead of porting the whole application to mobile platform which will make the application totally unusuable, designers seems to cut the original software into pieces. They created PS-Mix to cut and paste parts of images to create a new image layout, PS-Fix to serious image restoration and retouching, PS-Express to satisfy the general and basic needs of users, and PS-Sketch to create freehand sketches on mobile platform. All these applications are isolated parts of the native software. As hardware performence and interaction capabilities of mobile platforms can not support the capabilities of the native software, designers created new smaller applications which can fit into the capabilities of the mobile platform. Still, compared with the native software on PC, mobile applications are very limited in terms of precision and detailing. They are not designed for creating projects by professional designers or illustrators which requires long work hours, instead to create images in minutes for daily amateur users who mostly edit daily photos quickly just befor posting to a social media timeline (Tab. 17.2).

There are no PhotoShop versions exist for IVR environment but two software, TiltBrush and GravitySketch have been developed as three dimensional free hand sketching tools for IVR environment. As IVR is a three dimensional environment, it is not logical to create a software to edit an image which is a part of two dimensional surface. On the one hand, photo editors running in the IVR environment will be very unlikely, on the other hand, creating sketches with three dimensional strokes can be very functional for designers. GravitySketch and TiltBrush uses this idea: creating three dimensional strokes. Although these are not three dimensional modeling tools, user can create either two or three dimensional looking sketches (Tab. 17.2).

For any software designed to be used in IVR environment, biggest challenges are usability of command menus, precision and ergonomy issues resultant from the hardware geometry and weight. WIMP menu system is being used since Xerox Star 1981 and based on simply double clicking on an icon which represents a software or a file, to activate the software. It was designed to be used with a mouse pointer which is also very precise and easy to control in it's native environment: PC's. IVR systems, however, simulates the three dimensional immersive environment as we live in, and in our daily environment,

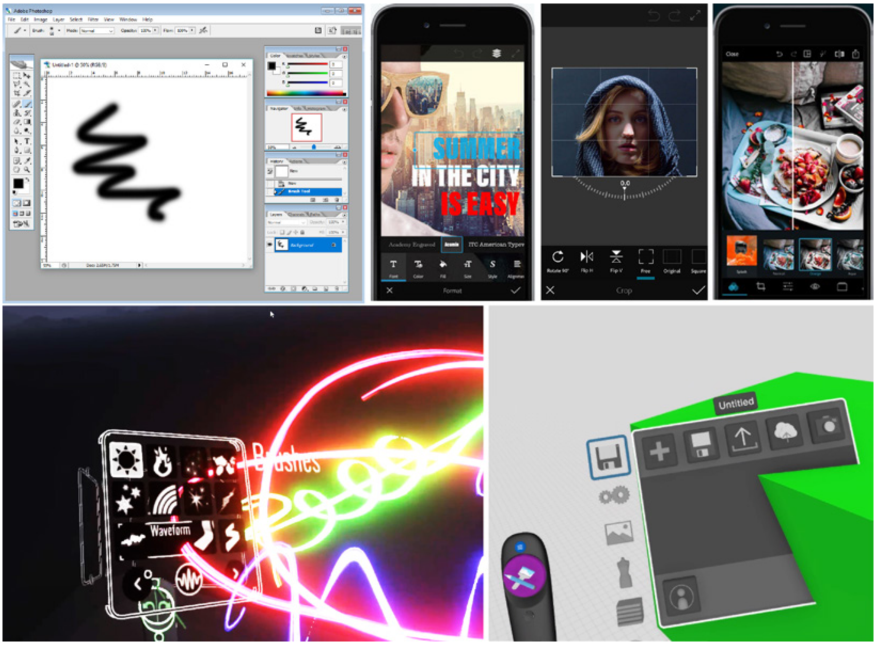

Fig. 17.1 - Studied two dimensional photo editing and sketching tools (upper row: photoshop variations. Lower row: TiltBrush and Gravity Sketch)

we do not interact with the representations of objects but we interact directly with the object. As menu commands are not real objects but representations of software, files or commands (all are abstractions of concepts) and as IVR environment is simulating the real environment which does not include any representations of abstract concepts, it is not very easy to create usable menu systems in IVR. Because menu items in IVR are also three dimensional objects like the objects users try to create, and as these two types of objects shares the same environment, inevitably they start to interact with the manipulated object resulting with the distraction of the user. Lack of precision in IVR tolls is another challenge. Mosty users interact with the IVR system with handsti-cks and while standing up position. Compared with the WIMP system, while users interact with the system in a seated position and arms resting on the table, IVR systems require more physical power as body movements cover larger areas (Montano Murillo, Subramanian and Martinez Plasencia, 2017) and moving arms instead of hands or fingers makes completing tasks which ne-eds precision very challenging (Seagull *et al.*, 2009). Entering symbols or text based information in a document by using an IVR system needs furter design

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Tab. 17.2 - Comparison of Selected 2D Photo Editing and Illustration Sotware by Platform

	PC WIMP Photoshop	**Mobile Touchscreen** Photoshop Mix / Fix / Express / Sketch	**IVR** TiltBrush GravitySketch
Software Capability	Photo editing Illustration Painting Freehand sketching	Several (at least four) different applications developed to fulfill some capabilities of the native software.	Only create line based illustrations in three dimension
Interaction Technology (hardware)	Mouse pointer, keyboard and optional Wacom tablet with special stylus.	Finger gestures or stylus on hand held tablet device.	IVR with headset and hand sticks
Interaction Technology (user interface)	2D Icons, pop up, sliding or drop down menus, Very wide range of command options.	2D icons, limited range of options ditributed in sliding, drop down or push up menus.	Icon like 3D buttons placed on a several 3D panels. Limited command options.
Precision Level	Pixel based precision exist for photo editing and illustration.	No pixel baset manipulation. Very limited.	Sketchy. No pixel based manipulation exist.
Screen Size	Adaptive to any screen size and resolution that operating system supports.	Adaptive to screen szze of the mobile device.	Constant size based on the IVR resolution

studies (Bowman, Rhoton, and Pinho, 2002). It is not a preferred option to use zoom in/out feature in IVR because this kind of rapid view changes can cause dizzines of the user. Last challenge is the geometry and weight of the system. The geometry and the weight of the headsets are unpractical for using in long durations where most designers prefer to work and concentrate long hours on a particular Project (Fig. 17.1).

17.4.2 3D Modeling Software

SketchUp is an easy to learn modeling software which is very popular among architects. Modeling technique of SketchUp is based on creating two dimensional profile section and creating a three dimensional model from it by using push-pull command. SketchUp is natively designed for WIMP interface. Menu panels are consist of icons which represents commands. User selects the appropriate command from the menu panels. Software can adapt to any screen size and resolution on the PC version. Therefore on the user interface there is enough empty space to place menu panels. As zoom in/out and camera orbit features are supported, users can zoom in or out or change viewing an-

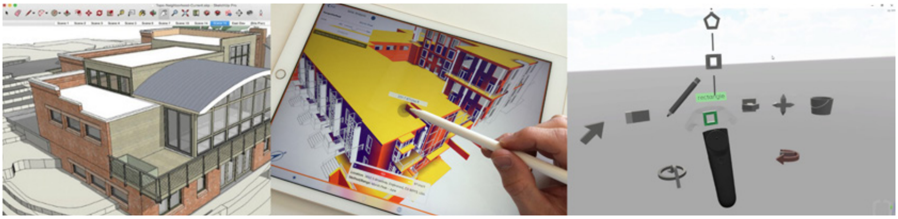

Fig. 17.2 - Three dimensional modeling tools (Left: Sketchup. Middle: FormIt. Right: VR Sketch)

Tab. 17.3 - Comparison of Selected 3D Modeling Sotware by Platform

	PC WIMP SketchUp	**Mobile Touchscreen FormIt**	**IVR VR Sketch**
Software Capability	2D line to 3D model Push – Pull technique	2D line to 3D model Push – Pull technique	2D line to 3D model Push – Pull technique
Interaction Technology (hardware)	Mouse pointer, keyboard.	Finger gestures or stylus on hand held tablet device.	IVR with headset and hand sticks
Interaction Technology (user interface)	2D Icons, pop up, sliding or drop down menus, Very wide range of command options.	2D icons, limited range of options ditributed in sliding, drop down or push up menus.	Icon like 3D buttons placed on a several 3D panels. Limited command options.
Precision Level	It is possible to create 3D models at any size by using zoom in/out feature.	It is possible to create 3D models at any size by using zoom in/out feature.	No zoom in/out feature. Not possible to model objects larger or smaller than human scale.
Screen Size	Adaptive to any screen size and resolution that operating system supports.	Adaptive to screen szze of the mobile device.	Constant size based on the IVR resolution

gle to view the work area for appropriate detail with easily controlled by mouse buttons and movement. Precise measurements can be entered to the system by the help of keybord and numerous keyboard shortcuts increase the speed of modeling (Fig. 17.2). Some researchers study on developing multimodal 3D modeling software to benefit the best features of both WIMP and IVR based modeling systems (Toma, Gîrbacia and Antonya, 2012).

SketchUp does not have a mobile version but a similar tool, FormIt, exist which uses the same modeling technique, push-pull, on mobile devices. For mobile devices, biggest challenges are the absence of the keyboard and mouse pointer, smaller screen size, and being mobile. For mobile version, a stylus and finger gestures replaces the keyboard and mouse pointer of PC. Using finger gestures dramatically decrease the precision level of modeling. Tapping on screen to activate applications or swiping to change page is acceptable for daily use but for modeling tool, precision and control on the geomety of the model is a necessity. Therefore, users prefer to use a stylus for more precision on modeling. As mobile systems mostly use virtual keyboards and it is not possible to interact with the modeling environment while keyborad is active on screen, modeling speed of the user decreases dramatically. Last challenge is being mobile. Mobile devices were designed to be portable. Therefore, size, peripherical devices and interaction techniques are limited. So, for a modeling task it is not a very suitable environment (Tab. 17.3).

17.5 Conclusions

In this study we carried out two case studies to understand the theoretical framework of how; interface, workflow, Ergonomics and User Experience changes when a software migrates from its native hardware platform to a new hardware platform. Two dimensional photoediting and three dimensional modeling software were selected to be investigated. Native and migrated software were investigated on three platforms and interfaces; PC-WIMP; mobile touch screen; and IVR. Presented cases support our hypothesis that if a video game or a software designed for it's native platform migrates to a new platform, functionality, usability, playability (for games), User Experience, user interaction and user satisfaction will change. This study aimed to discover the possible parameters of this phenomenon. Further studies are planned to measure the effects parameters on the investigated subject.

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18. Children as Superheroes: Designing Playful 3D-Printed Facemasks for Maxillofacial Disorders

by Patrizia Marti, Cecilia Goracci, Flavio Lampus, Lorenzo Franchi

Abstract

The paper describes a Human-Centred Design approach to developing customised facemasks for the orthopaedic correction of Class III malocclusions in children. The effectiveness of facemask therapy critically depends on patient's compliance with the recommended wear time, possibly ranging between 14-24 hours a day, over a time span of at least 9 months. Commercial facemasks are unaesthetic, uncomfortable and cause irritations due to the direct contact of plastic on the skin (Stocker *et al.*, 2016).

The research project SuperPowerMe develops a custom-made facemask to make the impact of the therapeutic intervention more sustainable in a critical stage of the physical and psychological child development.

Differently from commercial facemasks, SuperPowerMe is composed of 3D-printable biocompatible materials which make the device comfortable and customisable. SuperPowerMe adopts a gamification approach (Birk *et al.*,2016): a smartphone application provides games of increasing challenge where a superhero avatar wearing a facemask akin to the one worn by the child gains power fighting against monsters and other characters.

An ergonomic customised prototype facemask has been developed and will be soon tested at the Careggi Hospital in Florence, Italy.

Keywords: *Class III malocclusions, Children, Experience Design, Gamified therapy, 3D printing, Wearables.*

18.1 Introduction

Class III malocclusion is a craniofacial deformity characterized by a concave profile that results from retrusion of the maxilla, prognathism of the mandible or a combination of the two.At the dental level this skeletal relationship reflects into the prominence of the lower arch relative to the upper arch, or the inversion of the anterior bite.

This type of malocclusion has to be treated in childhood ideally before age 10, to improve dental occlusion and facial aesthetics, as well as to reduce the need for orthognathic surgery.

Class III malocclusion is treated using facemasks consisting of frontal and mental pads made from acrylic, connected by a quadrangular metal framework or a single midline stainless steel rod. The pads are only available in standardized shapes and in two sizes. In order to apply a forward traction to the maxilla, elastics are attached from an intraoral anchorage system to a cross bar extending in front of the mouth.

The effectiveness of facemask therapy depends on patient's compliance with the recommended wear time, possibly ranging between 14-24 hours a day, over at least 9 months. Commercial facemasks are unaesthetic, uncomfortable and may cause skin irritations due to uneven pressure by the standard anchorage pads. In a survey assessing acceptability of orthodontic appliances, facemask was rated as the least acceptable device (Abu and Karajeh, 2013). Beside aesthetics, children often complain about facemask bulkiness and instability, which compromise the treatment.

The objective of the project is to develop a custom-made and playful facemask to make the impact of the therapeutic intervention more sustainable in a critical stage of the physical and psychological development of the child.

In the following we describe the concept design of the mask illustrating all components and motivations for the approach.

Later we introduce the initial steps taken in prototyping the facemask and the related challenges. In the last part we present the future steps of the project.

18.2 Concept Design

SuperPowerMe is an ongoing research project aiming at designing facemasks for the early treatment of Class III malocclusions in children. The project is being developed by a multidisciplinary team of orthodontist doctors, designers, and technology experts with the involvement of children affected by Class III malocclusion and their families.

The project developed a concept of an innovative augmented facemask for the orthopedic correction of this maxillofacial disorder in children with the objective to overcome the limitations of commercial facemasks (poor aesthetics, skin irritation, poor Ergonomics) and to improve the acceptance by the young patients.

Commercial facemasks to treat maxillofacial disorders are seldom accepted by children. The design is solely focused on the functionality of the device without paying attention to other aspects of the User Experience like the aesthetics, Ergonomics, and motivating factors which are fundamental to make the therapy effective. Moreover, commercial facemasks do not fit adequately the child's anatomy, and the plastic may cause skin irritations.

SuperPowerMe aims at developing a wearable device using 3D printed biocompatible materials and customised design. The facemask can take several forms and colours depending on the child's preferences. Its aesthetics is co-designed with the patients.

In order to improve the acceptability and collaboration of the patients, SuperPowerMe adopts a gamification approach. An interactive game for smartphone and tablet is connected to the facemask and can be played only when the mask is worn.

The game automatically starts as soon as the child wears the facemask. It is designed as a never-ending adventure story which evolves with increasing levels of difficulty and challenges. The hero protagonist of the game wears a facemask akin to the one worn by the child, to facilitate the identification with the avatar. Super powers can be gained in two ways: 1) playing the game; 2) wearing the facemask for a defined number of hours a day.

The facemask hosts temperature and pressure sensors to monitor wear time and effectiveness of the therapy. Data related to wear time and pressure on the chin are collected and stored in a dedicated docking station, and downloaded each time the mask is placed on the unit. The docking station has two functions: 1) to recharge the batteries, 2) to automatically send the data to the dentist who can remotely monitor the effectiveness of the therapy.

18.3 State of the Art

There are no existing commercial alternatives to the concept of SuperPowerMe, which integrate all the features of the project together. A number of competitors provide solutions which only partially address the inconveniences of the current devices.

TheraMon (www.english.thera-mon.com/) and Dentitrac (https://somnomed.com/au/dental/product-range/compliance-recording/) developed microsensors to monitor wear time of removable orthodontic appliances.

Pads of marketed facemasks are all made of hard acrylic (Fig. 18.1). Different 3D-printable materials are being comparatively tested in our research. Among them, MED610 (by Stratasys Ltd., U.S.A.) and Polyamide 11 and 12.

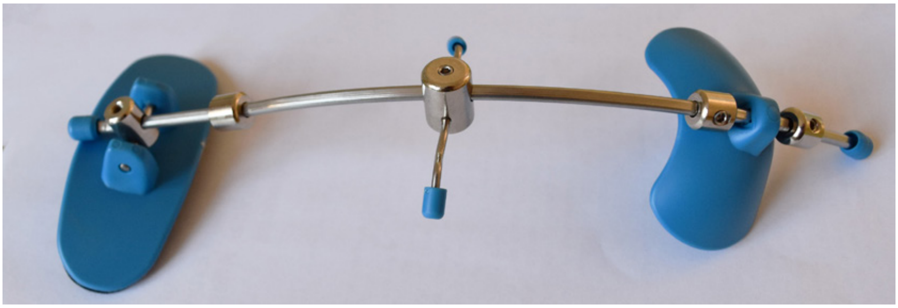

Fig. 18.1 - Commercial Petit Mask

These 3D-printable biocompatible materials have been used to custom-manufacture intraoral appliances for the treatment of sleep apnea (Vecchierini *et al.*, 2016). Polylactic acid is another biocompatible polymer that has been used in surgery and whose applicability in the production of customized facemasks deserves to be assessed (Wurm *et al.*, 2017). Additionally, 3D-printable silicones have been developed for the fabrication of facial prostheses and may be adequate to produce customized facemasks too (Jindal *et al*., 2017).

The project experiments with many of the above mentioned materials to identify optimal solutions related to the improved wearability of the device.

Regarding the facemask customization, the majority of commercial custom devices concern 3D-printed maxillofacial implants and prosthesis. The application to facemasks for Class III malocclusion is unexplored.

The introduction of monitoring and gamification strategies into the management of facemask treatment is also highly original and innovative, there are no similar commercial products on the market.

18.4 Mask Design

After the concept design, a prototyping phase started involving a child suffering from a Class III malocclusion, with the aim to develop a customised facemask adapted to his anatomy. As explained in more detail below, a 3D model of the patient's face was realised and used as a basis to model the chin and front pads of the facemask so to reflect the patient's anatomy.

The 3D model was later used to design the central bar whose length should be calibrated/sized to allow him/her to freely move without impacting the throat, as often happens with commercial facemasks. Metal bars of commercial facemasks usually have to be cut by the doctor to avoid injuries on the neck/throat.

More in detail, the facemask design process developed along four main steps:

- 3D data acquisition and object reconstruction;
- 3D modeling and design;
- selection of materials;
- 3D printing.

The steps are described below.

18.4.1 3D Data Acquisition and Object Reconstruction

The patient's face 3D model was acquired using a photogrammetry station (Face Scanner Maxi 6, Polishape 3D, Bari, Italy). Photogrammetry is method that allows to create a 3D model starting from a series of photos which preserve both the original shape and dimensions. Once the photos were taken, the software Agisoft Metashape was used to process them and to create a 3D model of the patient's face. This phase of the process is crucial and delicate since the acquisition method requires the patient to remain still during the operation. The procedure is easily accomplished with adults, but it is not equally simple with young patients. If the patient moves during the acquisition, the procedure has to be repeated several times before obtaining a complete and accurate 3D model.

Once the model has been acquired, a final check has to be done to verify the full compliance and accuracy of the measurements of the 3D model with the child's face.

18.4.2 3D Modeling and Design

Once the child's face model was acquired, the software Blender was used to design the customised facemask. The 3D model of the patient's face was used as a physical reference to design the front and chin pads in order to obtain a model perfectly fitting the patient's anatomy. The next step was to connect the chin and front pads with a central bar, whose length was carefully adapted to the anatomy and length of the child's face. This bar was not conceived just as a way to connect the pads but it was modelled following the profile of the child's face so to provide a comfortable fit, and avoid sight problems to the child since the bar is placed between the eyes (Fig. 18.2).

The process was iterated several times before obtaining an adequate fit both in terms of Ergonomics and technology requirements.

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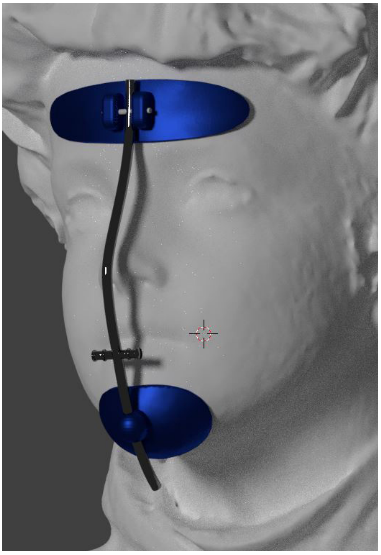

Fig. 18.2 - 3D model of the customised facemask

In fact, a digital facemask perfectly fitting the 3D model of the patient's face, may not result in a perfectly fitting of the 3D printed model. Therefore, the effort to optimize the process of modelling and printing was made in the experimental project.

18.4.3 Selection of Materials

A research on bio-compatible materials was conducted to identify the materials which could both avoid irritations on the skin and at the same time be flexible and robust to resist the traction of the elastic bands anchored to the intraoral anchorage system. Indeed, patients usually complain about the discomfort and abrasions caused by the daily use of commercial facemasks.

We oriented our research on materials with the following characteristics:

Biocompatibility: the facemask has to be worn for 14 hours per day, so it is absolutely necessary to avoid any negative impact on the patient's skin due to the prolonged exposure.

Suitability for 3D printing: the material can be 3D printed using one of the following techniques: fused deposition modeling (FDM), stereolithography (SLA), or selective laser sintering (SLS). FDM is an additive manufacturing process where an object is built by selectively depositing melted material in a pre-determined path layer-by-layer. The materials used for FDM are usually thermoplastic polymers and come in a filament form. In SLA, the object is created by selectively curing a polymer resin layer-by-layer using an ultraviolet laser beam. The materials used in SLA are usually photosensitive thermoset polymers that come in a liquid form. SLS is the process of creating objects from powders. The laser heats the powder fusing the particles in the powder together into a solid form.

Sturdiness: the material must be flexible and robust to resist the traction of the elastic bands anchored to the intraoral anchorage system.

The result of this research brought to identify the following candidates:

- Nylon PA12 an affordable, resistant and biocompatible material that can be printed FDM and SLA 3D printers;
- MED610, which is usually used in facemasks for the treatment of burns in children;
- Veroflex which is used for producing glasses;
- Nylon 12 with carbon fibers for the central bar. This material is particularly robust and can represent a good alternative to the metal which makes the central bar heavy to wear.

18.4.4 3D Printing

The first prototypes (Fig. 18.3) of the customised facemask were realised using an FDM Ultimaker 3. The orientation of the deposited layers was carefully considered to avoid any fragility of the structure.

Since the facemask has a long and thin shape, the traction of the elastic bands which anchor the mask to intraoral anchorage system can divide the filament layers and break down the central bar. To avoid this inconvenient, it was necessary to design the model so that the layers orientation was perpendicular to the elastic bands. This method proved to be successful.

18.5 Future Steps

The project has so far reached a maturity level to be turned in a clinical trial. This will be conducted at the Orthodontic Clinic of the Careggi University Hospital, Florence, (Italy) under the supervision of Prof. Franchi.

The clinical trial will compare the efficacy of the customized facemask versus the conventional facemask in pre-pubertal patients with Class III malocclusion. The trial will also assess patients' acceptability and compliance of the

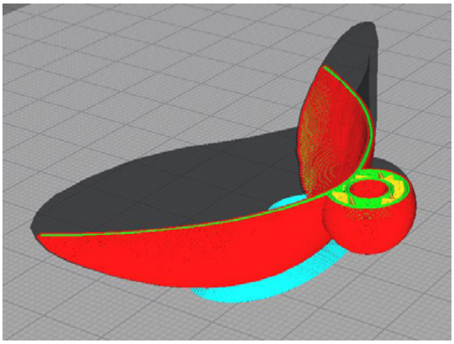

Fig. 18.3 - Detail of the chin support 3D model, ready to be printed

2 types of facemasks and also the occurrence of complications (skin and lip irritation, gingival recession).

Beside the evaluation of the efficacy of the facemask during the first trial, next steps of the project will regard the design and implementation of the embedded electronics, the development of the game and the creation of new designs to enrich the aesthetics of the facemask.

During the design phase, children with Class III malocclusion interviewed by the therapist, expressed the wish to personalise the facemask using for example the symbols of the favorite football team, or the favorite cartoon characters, or simply the most preferred colours. Very preliminary attempts to personalise the face masks and submit the design to the young patients' evaluations were accomplished in different phases of the design process. In some cases, feedback was collected from the patients themselves, in the majority of the cases from the therapists and the parents during interviews and participatory design activities. Children were generally reluctant to provide their feedback. Most likely their previous experience with current face masks made them suspicious and unable to imagine a playful way to use the mask. Interviewed parents were keen to collaborate, seeing the project as a concrete step ahead in the therapy. The therapists who are currently collaborating in the project are firmly convinced about the positive impact of the research for the quality of life of their patients.

Embedded electronics. A custom-made electronic board, equipped with sensors is currently being designed. It will allow to track and store data about temperature and pressure on the front and chin of the child in order to monitor the actual wear time of the facemask. A docking station will be also developed to allow to recharge the battery, store the data coming from the sensors and eventually send the data to the therapist.

Game design. A simulation of the video game has been also developed to be evaluated with young patients (Fig. 18.4). The game design started with a benchmark study articulated in the following steps.

- *Analysis of titles published a few years ago but still in vogue.* The purpose was to understand the characteristics that allowed them to be played assiduously for a long time, since our game is supposed to be played for several months to make the therapy effective. Examples of game included in this category are: 1) World of Warcraft, a PC-based MMORPG game (Massive Multiplayer Online Role-Playing Game) developed by Blizzard Entertainment in 2004. It is still very popular within a community of active of players, mostly driven by the competition. It is articulated on one single never ending plot where the player can create his avatar and take the challenge s/he like; 2) League of Legends, a MOBA game (Multiplayer Online Battle Arena) released in 2009 by Riot Games. Players can choose their avatar with unique abilities to combat is a closed arena. To win, both the skill of the individual player and group strategies are necessary; 3) Minecraft, a sandbox and survival game released in 2009 and created by a Swedish programmer Markus Persson, acquired by Microsoft in 2014. The player enters a virtually infinite and randomly generated world in which, besides to complete some basic missions, has to survive to hunger and enemy attacks.
- *Analysis of titles played for several hours a day:* Football games (eg FIFA), Multiplayer First-Person Shooters (e.g. the Counter Strike or Call of Duty), Management games (e.g. Simpsons), Role-playing games (e.g. Pokémon) and Racing games (e.g. Mario Kart) are all characterised by never ending plots and high competitiveness. An inspiring example is the Management Game "The Simpsons" released by Springfield. The game exploits a temporal factor: every activity, to be completed, requires a certain amount of coins and time to be accomplished. For example, the construction of a building requires a high number of coins and twelve hours to be completed. This concept proved to be useful for the purposes of our game: rather than involving a child in gaming for a long period of time during the day, the challenges can be divided into several daily sessions of a few minutes each to get closer to the objective.
- *Game-based App for smartphone to support behaviour change.* Examples include: 1) QuitNow! to quit smoking. The app sends an alert when an objective is reached and reminds about the related health improvements; 2) Zombies, Run! Aims to stimulate running. The player has to survive a zombie invasion running for a definite time. In both cases, time is a key factor of the game.

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- *Game-based app with medical / health purposes.* Examples include: 1) Philips Sonicare for Kids, a customizable electric toothbrush for children to use together with a game developed for smartphones and tablets where the child will have to help a pet to clean its teeth and defeat the bacteria of mouth; 2) Bayer DIDGET for Nintendo DS, a blood glucose meter produced by Bayer. The results of measurements are converted in points that can be spent during the game to unlock new levels and customizations.

From the benchmark analysis, the following features were selected for our game design: a single never-ending plot articulated in smaller stories to give the impression of improvement; interaction between virtual and real world through the use of objects (e.g. face mask) present in both; simple mechanics tailored to young patients; use of notifications to reward the player. We deliberately decided not to design a community-based game due to the young age of our target. The social aspect of the game was realised with notifications like: "Congratulations! You are ranked among the top ten players of the game!".

The main character of the plot is the elf Araton, the strongest among the forest's elves, who lives on the slopes of a giant tree together with other elves. The tree produces fruits which are the only source of food for the elves. These fruits are so delicious that the tree is constantly target of the attacks of evil creatures. Araton has a secret weapon, a face mask that allows him to run above the bark of the tree without ever getting tired and to throw waves of energy capable of destroying the enemy. The aim of the story is to guide the sympathetic avatar in climbing the tree and defeating the evil entities that infest it stealing the fruits.

The game has a vertical development where the elves have to jump from one leaf to another, destroying enemies so as to increase the overall score. Some of them will carry baskets containing some stolen fruits, which can be harvested once the enemies have been defeated.

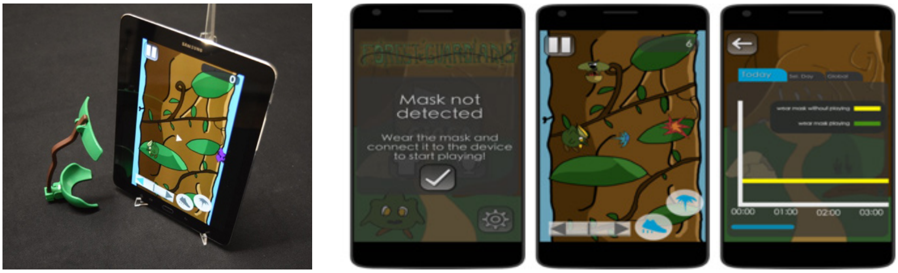

Fig. 18.4 - A simulation of the game associated to the facemask

The scoring system was designed according to the following rules:

- 1 point for each defeated enemy;
- 5 points for each fruit harvested;
- 5 points for every ten minutes of "passive" play, that is for the wearing time of the face mask during the day by the child without playing calculated by the embedded sensors.

The current version of the game provides real time feedback with motivational cues to stimulate the child in wearing the facemask. Personalized notifications and rewards (e.g. "Congratulations you have reached level four! You will get more power tonight while sleeping with your face mask mask") are provided during the game.

A prototype version of the game was successfully tested with three children who did not suffer from Class III malocclusion with the objective to evaluate basic dynamics and the overall concept. A further step will be necessary to involve young patients with Class III malocclusion to fully evaluate the prototype before starting the technical implementation.

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19. Studies on Ergonomics of Immersive VR as a Design Environment with a Focus on Tools and Interfaces

by Çetin Tüker, Hasan Taştan,Togan Tong

Abstract

This paper presents new Immersive Virtual Reality (IVR) tools attributes and capabilities and proposes to design in architecture and proposes a framework for their specification, development and evaluation of Ergonomics. In our research, two case studies were conducted with architectural and graphic design students.

In the first case study, the focus is on object visualization skills as part of spatial skills. The study was carried out on two separate groups as "IVR" group and" paperpen "group. To increase the likelihood of each participant starting training at the same point, it was stipulated that the students who would participate in the study had not received any technical drawing training before.

In the second, two IVR which have different user interface systems were generated to design membrane system using two separate ways for the participants. In the first, the participants could interact directly with the virtual objects. Another virtual environment included in the menu, button and sliders which are similar to WIMP (windows, icons, menus, pointer) interaction. The difference between the two environments is that they are different regarding design environments as well as their interfaces.

The participants' interactions with these environments were recorded via video of the participants' movements and screen capture video which viewed movements. As a result of this study, the researchers have examined the Ergonomics of IVR as designing medium on two types, both the interface system and the tools in these systems.

Keywords: *Immersive virtual reality, Virtual reality, Usability, Design technology.*

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19.1 Introduction

Recently, the new wave of Immersive Virtual Reality (IVR) systems have developed because of the affordability. Although these developments are partially included in scientific researches, the hardware and software improvements of IVR are made under control of the commercial sector leadership and enthusiasts of this field (Anthes *et al.*, 2016). These developments have changed the Human-Computer Interaction (HCI) due to the characteristics of the changing media structure.

While the user views via 2D screens and interacts objects with keyboard and mouse in monitor-based systems (Satter and Butler, 2012), IVR systems use 3D-based controllers that enable gesture-based interaction. It is required to investigate issues such as human interaction and Ergonomics so that the specific use of IVR for the productivity of various production areas is ensured. However, today's studies on IVR focus on technology medium itself and aspects of that rather than user interaction (Boletsis, 2017).

The architectural, engineering and construction (AEC) industry is pretty based on digital modeling, simulation and visual communication to ensure that a project is satisfying in high quality (Heydarian *et al.*, 2015). Because of these, CAD technologies are continuously developing in the AEC, besides the usage of analog tools. In addition to them, IVR has a widespread potential for scientific research and commercial use in AEC due to their direct manipulation, situated and body-scale interactions and more expeditious and powerful of simulating reality (Bowman *et al.*, 2006; Bowman *et al.*, 2001; Brooks, 1999).

While the studies in User Interface areas on IVR systems have helped to understand the general components of these systems, the research to be conducted within the main framework of human interaction in architecture will reveal which ergonomic, environmental, technological and representative parameters can be important in design process. The main focus of this study is to examine parameters such as the interaction and ergonomic relations of the user with the interface, input and output tools in IVR in the early stages of the architectural design process and to try to understand the usability of the system based on these parameters.

19.2 Background

2D, 3D representations are produced to design and simulate the final product of AEC and also to ensure communication between stakeholders. Beside usage of analog tools, CAD and BIM systems as digital tools are constantly open to development. In addition, the new wave IVR which have recently become cost-effective are being tried to be included in the design and design review areas of AEC with topics such as simulation and collaboration.

Various studies about HCI on IVR (Satter and Butler, 2012; Navarre *et al.*, 2005) deal with in general terms and are not sufficient for integration of IVR in AEC. On the other hand, the conducted studies in the AEC are that seek to answer how IVR systems can be used in their design processes. They have been researched for usability on low cost preproduction prototyping or on different assembly techniques in industrial design and various engineering fields (Oberhauser and Dreyer, 2017; Wolfartsberger, 2019; Hilfert and König, 2016). In architecture, the more focus is on design review or energy simulations via finished product rather than the use of the experiential structure of new wave of IVR systems in the design phase (Paes and Irizarry, 2018; Sun, Hu and Xu, 2019; Heydarian and Becerik-Gerber, 2017; Paes, Arantes, Irizarry, 2017; Vorländer *et al.*, 2015; Heydarian *et al.*, 2015). In fact, various studies conducted in the past on the use of Immersive Virtual Environments in the early phases of architectural design process (Donath and Regenbrecht,1999; Donath and Regenbrecht,1996). However, new opportunities have arisen on HCI by eliminating the hardware and software limitations of these systems. The research of Klerk and others with using mobile VR system is among the most recent studies in this area (de Klerk *et al.*, 2019). Klerk and his team investigated the usability of maquettes at different scales in early design stages in mobile VR with voxel modeling technique and demonstrated this in a number of ways. However, the modeling technique in their study has several limitations in modeling free-forms.

In our research, we conducted two separate studies. The first case study is related to the use of sketch for educational purposes, and the second cased study is related to slider-based and direct-manipulation methods to model free-form structure.

In the first case study, there are two main areas that researchers focused on; (a) training of object visualization skills of participants; (b) investigating the usability of the IVR hardware and educational software in the context of design education.

In the second case study, there are two main areas where researchers focus; (a) differences and similarities in modeling by using two different modeling methods such as slider-based which is similar to the WIMP interface with the structure of menu and icon and direct manipulation which is the method of different studies in the IVR; (b) investigate the usability of IVR hardware and software in the context of design.

19.3 Method

The first case study was carried out on "IVR" group and "paperpen" group. IVR technologies have been used as training software and hardware. In both groups, front, top and right views of the target object was displayed to students and they were asked to draw the isometric view (paper-pencil), or a line-based 3D model (IVR) of the target object (Fig. 19.1).

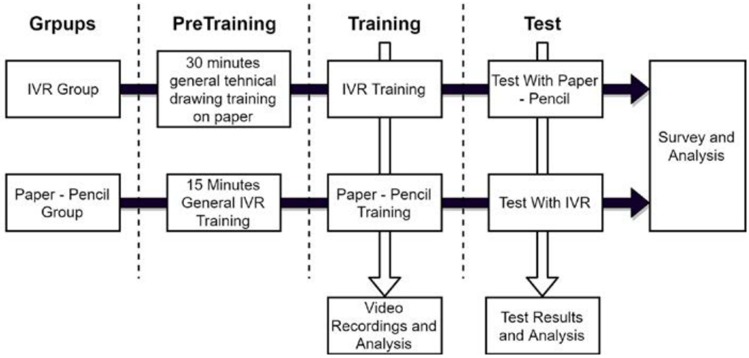

Fig. 19.1 - Schematic view of the first case study design

The second study was conducted on the use of two different design applications such as "Slider-based" and "Direct Manipulation" in IVR by the same people. To increase the likelihood of each participant starting the application at the same level, the participants were given pre-training to use the IVR tools before the using application. In both applications, users were informed about the applications and asked to design a membrane structure using two separate interfaces. In these two separate applications, the the design environment, the methods of modeling and the way of using the tools were different (Fig. 19.2).

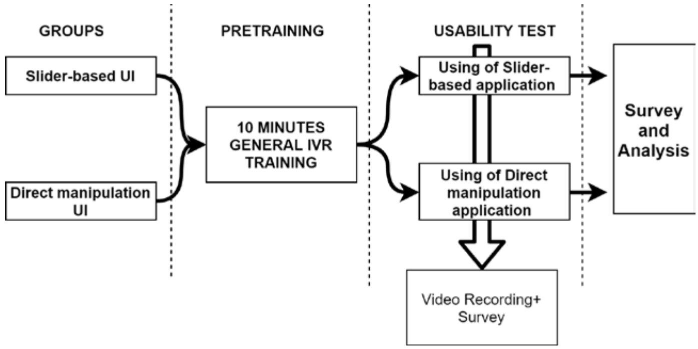

Fig. 19.2 - Schematic view of the second case study design

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19.3.1 Participants

In the first case study, graphic design students were selected as subjects as they were not trained in technical drawing before. Paper-pencil group was consist of 6 males, 2 females and IVR group was consist of 5 males, 3 females. 2 field specialists were mainly focused on the usability study of the used hardware and software.

In the second study, professional architects and field specialists who previously used different CAD and BIM software were selected as the subjects of the research. The study group consisted of 6 men and 6 women. 2 field specialists (they were a PhD candidate of architecture in digital environment) were mainly focused on the usability study of the used hardware (IVR System) and the software developed.

19.3.2 Hardware and Software

The virtual reality hardware HTC VIVE was used as the hardware and the game development and Unity (www.unity3d.com) was used as the programming environment. HTC VIVE is a head-mounted headset that provides a stereoscopic image. Two handstick controllers are used to interact with virtual environment. VIVE allows the user to move freely within an area of 3x3 meters.

In the first case study, the prototype software imitates drawing lines on paper. The student will be shown the front, top and right views of the target object, and he / she is asked to draw the three-dimensional model of the target object in IVR environment using drawing tools supplied by the prototype IVR modeling software.

In the second case study, two separate controllers were used to design the “Slider-based” application. The interface menu, which includes slider and icons for material changes, was connected to first controller, and the user held the controller with one hand and used the menu with the second controller. In “direct manipulation”, the user designed the membrane structure with moving the vertex which is cube in the + z direction via a single controller.

19.3.3 Data Collection and Analysis

Data is collected through videos recorded during tasks, and surveys with open ended questions. Researchers firstly studied the qualitative data and coded the concepts by using thematic content analysis and coding techniques as mentioned by Saldana (Miles, Huberman and Saldañaes, 2014). In the next step, these codes were grouped into more general components.

After coding process of videos, surveys and test recordings, fuzzy-logic cognitive mapping technique is used to visualize and further analyze the network of components mentioned by the participants. A cognitive map is used to create a relational network of the analyzed process as a cause-result network connected by causation links. Eden and Ackermann mention (Carbonara and Scozzi, 2006), there are no generally accepted conventions to create and analyze cognitive maps. Therefore, researchers use several methods or software to analyze the qualitative data. It is possible to see cognitive mapping technique in several studies in design literature (Eden and Ackermann, 1992). Mental modeler software (www.mentalmodeler.org) is used to create the network and to calculate relational values.

19.4 Results

In the first case study, centrality values, and driver-receiver factors of the networks computed by the software. Higher centrality values shows the most influencing components. Driver factors have causative effects and receiver factors are the resultant nodes of the network. Five most highly scored components in centrality values of each group (Tab. 19.1) and five driver-receiver factors of the each networks are listed (Tab. 19.2).

For IVR group,the highest centrality value componet is related with the usability of the freehand drawing tool. Next components are related with the visualization skills of the students. The only positive component among the five is related with the attributes of the IVR environement, that is the easiness of visualizing in IVR. Fifth component is also related with the issues of the capacity of the drawing tool (Tab. 19.1).

For paper-pencil group no factors mentioned related with the tool and environment (basicly pencil and paper). The only positive driver factor is repetitive training (Tab. 19.1). Negative driver factors are related with visualization skills, geometry and geometric complexity of the target shapes, and drawing notations. Resultant factors are related with the perceived difficulty and thinking duration (Tab. 19.2).

Driver and receiver factors for IVR is mostly negative. One of the the two positive factors is an attribute of the IVR environment. Lack of precision of the

Tab. 19.1 - Components of network analysis with highest five centrality values for each group

IVR Group Components	Effect	Area	Centrality
Drawn lines become too complex when more lines added	Negative	Tool	2,17
Difficulties in visualizing 2D object in 3D	Negative	Visualization Skills	1,63
Difficulties in visualizing mentally and compare with the VR result	Negative	Visualization Skills	1,41
Easiness of visualizing in VR from every angle	Positive	Visualization / Environment Attribute	1
Lines drawn in space are not parallel	Negative	Tool	0.94
Paper- Pencil Group Components	**Effect**	**Area**	**Centrality**
Difficulty of Visualizing in 3 Dimension	Negative	visualization	2,75
Process of visualization/drawing/re-visualization loop	Negative	Visualization	1,5
Misunderstanding & wrong visualization while creating three dimensional visualizations	Negative	Visualization	1,5
Geometric Complexity	Negative	Visualization	1,5
Repetitive Exercise Improves	Positive	Training	1,25

drawing tool and difficulties related with the hardware performance are negative factors. Participants mentions repetitive exercise improves visualization skills and they had difficulties in understnding technical drawing notation. Last two resultant factors are related with the capacity of the designed tool and with the physical ergonomy of the equipment (Tab.19. 2).

For IVR group users are complaining about they had to draw lines by freehand without any straight or paralel line support so the lines drawn in the space becomes too crowded and complex. The resons of this can be; (a) drawing straight and parallel lines is not supported, so as lines are not clean and clear, visual complexity increases rapidly; (b) as users experience difficulties in visualizing, they add unnecessary lines. Graphic design students have sufficient training in freehand drawing on paper, but they have no previous experience with the IVR drawing tool. So, they experienced difficulties in drawing straight and parallel lines in IVR. For future development these strategies can be followed; (a) adding straight and parallel lines features which will make the tool more usable for professional modeling; (b) improving the line drawing algorithm to create less scattered lines for training purposes. It can be hypothesized that software support can reduce the efficiency of visualization training.

Tab. 19.2 - Driver and receiver factors of each group

IVR Group Driver Factors	**Receiver Factors**
Easiness of visualizing in VR from every angle (positive – visualization / Environement Attribute)	Drawn lines become too complex when added more lines (negative - tool)
Tool is not precise (negative - tool)	Feeling pain in the eye (negative – equipment ergonomy)
Repetitive exercise improves (positive - training)	
Difficulties in understanding technical drawing notation (negative - lack of training)	
Technical difficulties related with hardware (negative - tool)	
Paper-Pencil Group Driver Factors	**Receiver Factors**
Repetitive exercise improves (positive - training)	Thinking duration affected from several factors (negative - visualization)
Difficulties to follow projections in different views (negative - visualization)	
Curves and corners makes drawing harder to visualize (negative - geometry and visualization)	
Invisible lines makes it harder to visualize (negative - drawing notation and visualization)	
Holes and voids in geometry (negative - geometry and visualization)	

Other three components of IVR group, are related with the visualization skills. For paper-pencil group also, difficulties in visualization were the most mentioned components. Visualizing a 3D object by using it's orthogonal projections such as plan and side views is not an easy task, therefore it is not surprising that students mentioned these factors in both groups.

Last factor is the attributes of IVR environment while visualizing the target object. IVR system makes it easier to see objects in three dimension. So they can roam around any virual object created in IVR and observe it from any point. So this attribute helps students to reduce their mental loads. This is not possible on paper surface. Any isometric drawing of a 3D object on paper is still a 2D representation without any depth information. Therefore paper-pencil sketching needs more mental visualization performance.

In the second study, the results of the experiments were examined under three titles as best, worst and required improvements for both applications. These three topics were covered in the sub-headings: GUI, modeling, navigation, hardware and rendering modes depending on the surveys (Fig. 19.3, Fig. 19.4).

The use of menu which is similar to the WIMP interface structure in the "slider-based" application is highly emphasized due to difficulties in GUI interaction. However, with the advantage of similarity, the ease of modeling in this applica-

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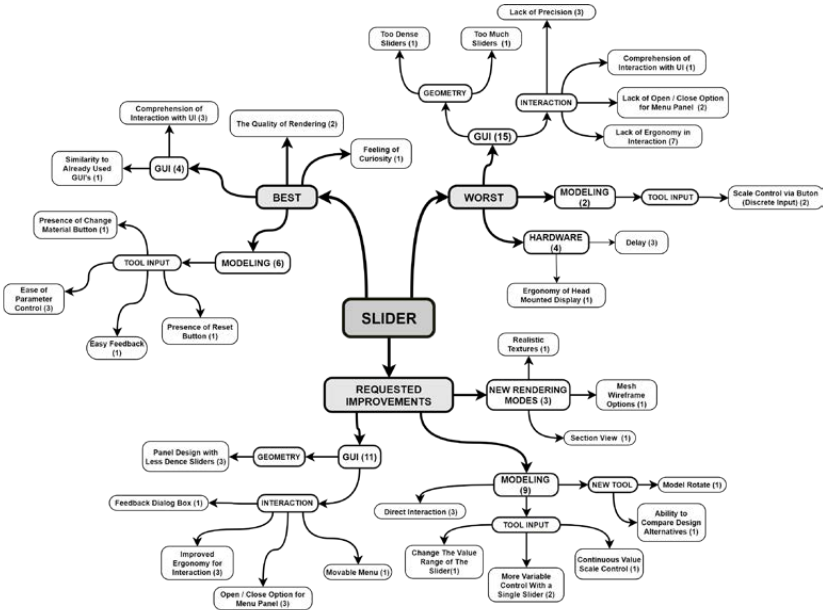

Fig. 19.3 - Schematic view of the first case study design

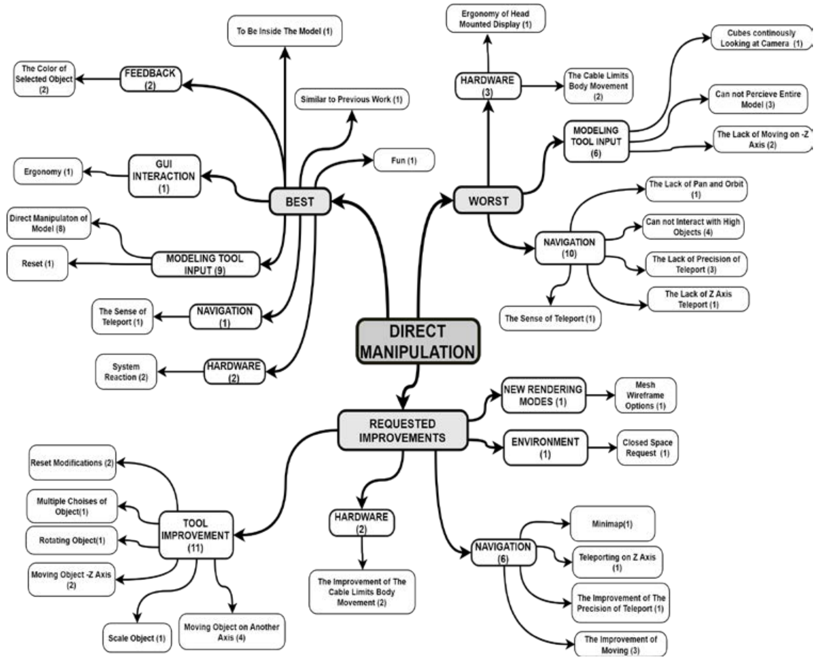

Fig. 19.4 - Schematic view of the first case study design

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tion is another issue indicated by users. Users requested that the menu usage interaction in this application be brought closer to the direct interaction format.

The way of modeling with gesture-based interaction is an affirmative issue in "Direct-manipulation" application. But, navigation difficulties such as the precision of teleport and not interacting with high objects are also emphasized as the other issues. Users requested mostly that the improvements of modeling features such as reset, scaling, rotating.

These investigations have shown that; a hybrid system which will be handled together these applications, instead of a clear distinction such as "slider-based" or "direct manipulation", would be more beneficial in the modeling application that can be used for architecture in IVR. In addition, it is useful to replace the controller sets with new architecture specific tools to enable more efficient and effective modeling of architectural forms in IVR.

19.5 Conclusion

In this study, usability of the IVR hardware, environment, and a special software were investigated within the context of three-dimensional visualization training for graphic design and the different form of modeling techniques students for architects. The data was collected in the form of surveys with open ended questions, video recordings of the sessions, and researcher observations.

In the first case study, according to the analysis of the data, it is seen that, although IVR tools used in this study were very simple and usable with almost no training, they still need more improvement. The most outstanding need for improvement is related with the precision of the line creating tool. While, on one side, drawing with a pencil on a paper in a seated position, it is more easy to maintain a eye-hand control, and create a fairly good precision with proper training. On the other side, while drawing with sticks in hands by arm movements in the space and standing on foot, it is harder to maintain precision control with arm movements and clearly the former is more tiring in long study sessions.

In the second case study, analysis based on two different modeling methods showed that a gesture-based use in IVR was more efficient due to the structure of this medium. But on the other hand, slider-based application is quite simple for users to understand because it is similar to the applications in the monitor-based system that they used before. According to these analyzes, the IVR system can be made more effective with a new application by customizing the controller according to architecture and addressing the productive aspects of both applications.

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20. Experience Design for Children Through an Interactive Space – Escape the Room Game

by Sabrina Parenza, Luiza Grazziotin Selau, Carla Souza, Rodrigo Pissetti

Abstract

This paper presents the problems of Brazilian education regarding the level of teaching contents basic knowledge and the presence of the museum as a means of interaction, used by schools, with the themes presented in the classroom.

The union of formal education (school) in a nonformal environment (museum), which offers knowledge and instigates learning, helped to express, in a playful way, the contents seen in class as a resource for the education of children. These environments on their own already have gamification characteristics where the visitor learns by observation and interaction, which makes them a good option when it comes to interactive virtual experiences.

Based on an exploratory research that goes beyond bibliographic record, it also contained field research and interviews with related professionals. This "background" improves the analysis and helps the objective of bringing the best educational and functional experience.

The analyzed target audience represent a core moment of the formation of a person and its education.

The methodology was based on experience and Interaction Design, as proposed by Passos (2010), merging it to the ideas of other authors from the design area.

The result of this paper is a project of a video game planned to encapsulate the basic knowledge fields and its content axis based on Brazilian education. Also, it highlights the potential of experience design as the main pillar to solve problems in design proposals.

Keywords: *Co-creation, Design ethnography, Team ethnography, Digital tools, Digital research, Distance design, Cultural sustainability.*

20.1 Introduction

Basic education in Brazil presents many problems surrounding knowledge of the disciplines that are essential to the construction of the intellect of children and adolescents. It is mainly based on textbooks as a form of teaching, which, in the current scenario of the national education system, is inefficient (Lima, 2016). In order to diversify the format of the learning occasions, visits to museums are carried out.

Design can work in favor of this scenario to help in the search for incentive to moments of complement or reinforcement of studies. Based on the exposed scenario, this paper proposes the creation of an educational game. The game project is based on the Brazilian national curricular basis for the 6th grade of elementary school.

The theme of the game is intended to help in the way the school contents are presented to the students, with an immersive atmosphere so that the user feels able to understand the information that is received and transforms it into knowledge, besides promoting the stimulation of cognitive abilities.

These skills consist of learning, attention, memory, language, thinking, reasoning and creativity (Papalia and Feldman, 2013), encouraging students and teachers to interact within the classroom with the help of this project and transposing the experience of the game into the teaching environment.

This proposal aims to generate empathy, encourage discussion and instigate the development of children. To achieve these purposes, color is used as a means of transmitting sensations and ideas, as well as the audiovisual resources to promote experiences, and through the operation and principles of the design of experience and interaction create an intuitive game that exposes the school contents in a playful way.

20.2 Background

The main motivator for the start of this paper is the result of researches that proves that the level of basic knowledge from students during the elementary school has declined. On public schools, the proportion of students that have learned what is considered to be suitable is: 50% for grammar, 39% for mathematics on the 5th grade and then 30% for grammar and 14% for mathematics on the 9th grade, this data is from 2015 (IDEB, 2016). These results help to evidentiate the inefficiency of teaching methods that are essentially connected to reading books.

From the 6th grade and above there is a transition from having only one generalist teacher to multiple teachers, one for each subject (BNCC, 2017). This matches with the transition from childhood to adolescence, in which many changes will happen, like: Nerve impulses still in development and that correlate with emotion and instinctive reactions; the analysis of multiple perspectives and strategies of memory get significantly better; growth in pragmatic and comprehension abilities; regularization of emotions and humor oscillations (Papalia and Feldman, 2013).

This way of teaching and learning, found on schools, is called formal education, while there also is informal education (through parents, friends, theaters and others) and nonformal education, that comes from the intention of teaching formal education content in places like museums, science centers etc. (Vieira, Bianconi and Dias, 2005).

With this comes the realization of the importance of closing the gap between the classroom (formal education) and nonformal education, like a museum, considering the benefits that it would bring to the children for bringing new perspectives of the subjects reviewed in class. In an environment that its primary function is to encourage curiosity for knowledge, promoting public opinion surrounding themes that cover the daily life of a citizen (Wagensberg apud Gruzman and Siqueira, 2007).

The public becomes essential to this environment, allowing them to interact with the place. This way, the interaction wouldn't only be physical but also relate to the cognitive and affective side. Motivating its public development.

This union of interaction and experience created by the museum and the educational content is made through experience design, having Interaction Design as its main collaborator. Since experience design takes into account not only characteristics from the created object but also characteristic from the user, the use context, the possible actions and reactions, enriching the User Experience that goes along with many design specialties (graphics, interaction, product, interiors etc.), and also subjects that study human behavior (Pinheiro, 2007).

In Interaction Design, since it relates to experience design, we investigate the use of elements and the target domain from a usercentered development approach with a plan supported by the intended use of the product, its target domain and relevant practical considerations. For the evaluation to be successful the design should be expressed in a way that users can interact with (Preece, Rogers and Sharp, 2005).

Taking into consideration the desire to assist in school education in Brazil, the definition of the final project for the paper as a virtual product has as its objective and justification the possibility of reaching a much larger number of users. For its present interactive mode, a museum already resembles a game that in a virtual way presents a proposal more attractive to children than a virtualized museum. Making room for possibilities to implement the knowledge present in the Brazilian curricular base in playful ways.

20.3 Methods

The methodology of this paper was divided in two stages: the first one following scientific methodology and the second one being design methodology. The method applied in the first stage consists of exploratory approach research for providing greater familiarity with the problem (Gil, 2007), the bibliographic structure was based on studies referring to materials already elaborated and published on the subject. To better understand the target audience, their needs and ways of capturing their attention, an interview was conducted with two psychologists who have knowledge about the subject matter.

Also, a field study that by purpose seeks the direct observation of the activities in a certain place with the purpose of understanding the proposed questions, which may contain interviews (Gil, 2007) to identify the existence of certain factors listed during the bibliographic survey and with what way and constancy these are implemented in a museum.

Thereafter the architectural design method stage based on Passos (2010) began, which unites four design approaches, prioritizing approaches and tools compatible with this project (Interaction and User Experience Design). In the context phase, analyzes were performed by authors such as Löbach (2001) and Munari (2006). The other steps combined tools, besides those belonging to Passos (2010), found in the design methods of Baxter (2000) and Design Thinking from Vianna (2012).

Thus, the architectural design methodology is divided into six stages.

- Context: collection and synthesis of data relevant to the project, exploring the possible opportunities and requirements to meet the needs of the user in this scenario. By means of: information gathering, identification of objectives, analysis (configuration analysis, public analysis / social relation and function analysis) and requirements.
- Scope: determines the issues related to the visual identity of the project, what is sought to convey and how to expose it. Tools used: concept (conceptual map and semantic panels), functionality and refinement of information.
- Structure: intended for the creation of alternatives, organization of functions and prediction of user actions regarding the interface and deci-

sion of the best option for each topic. Tools used: project map, task flow, content design and function, and creativity tools.
- Skeleton: represents proportion details, position and development of the screens and the game. Tools used: information design and Interface Design.
- Surface: the visual improvement of the whole project.
- Execution is the testing phase and production of prototypes and/or commercialization.

This methodology has as objective the realization of an interface that is more efficient, functional and oriented to the needs of the user, because its design structure doesn't only take one author's approach, it actually incorporates several authors according to the context in question (Passos, 2010), so that the project becomes unique and has an elaborate logic for its scenario.

20.4 Results

The evaluation of interactive and virtual museums (from Brazil and other countries), based on the analyzes, verified the differences and ways of applying the same concepts and/or resources in these environments. The interview with professionals in the field of children's psychology had the function of defining the parameters of the target audience. The synthesis of these analyzes contributed to the generation of the project requirements, the concept of the project and the creation of semantic panels representing the interest group, project expression and visual theme that was refined and defined with trends research. The organization of the functionality transformed the design requirements into technical parameters, allowing a better visualization and comparison of the information presenting how the organization of the same would be done (Passos, 2010). Dividing these parameters into:
- Degree of instruction and User Experience: separating the possible users and listing the level of knowledge of each of these;
- Graphic elements and description: highlighting each of the items and what their application and what they would have of information and/or interaction.

With these defined factors, the user interface project stages were applied: screen organization and task flow that prioritized the User Experience since this was the main pillar of the game and the project, in parallel to the definition of game design in terms of play style.

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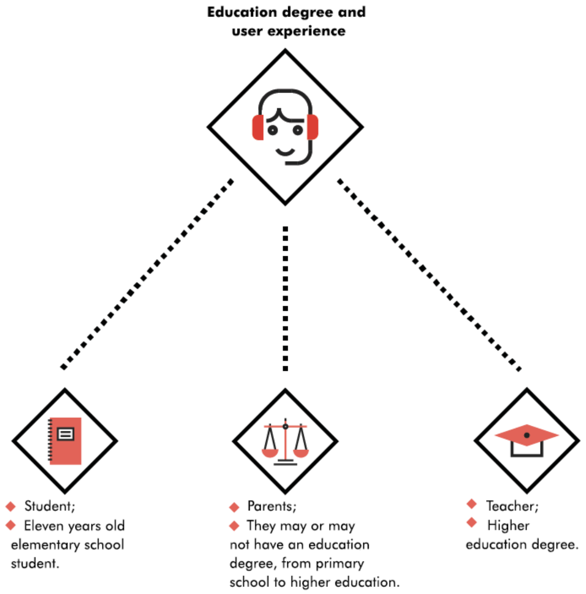

Fig. 20.1 - Division of possible users and their degree of education

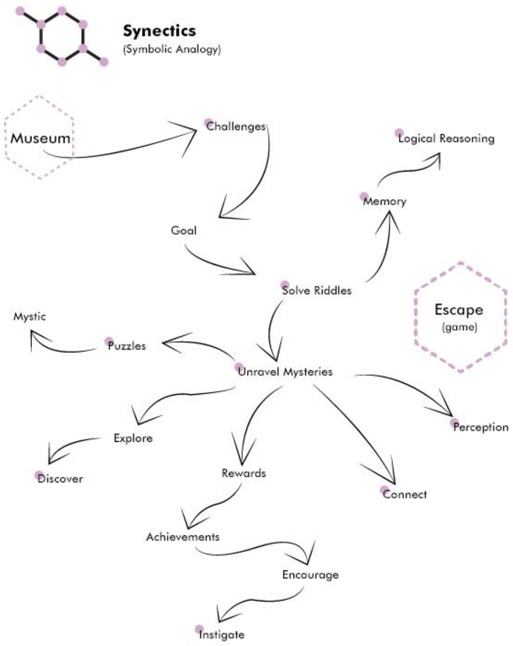

Fig. 20.2 - Synetic tool to help game design

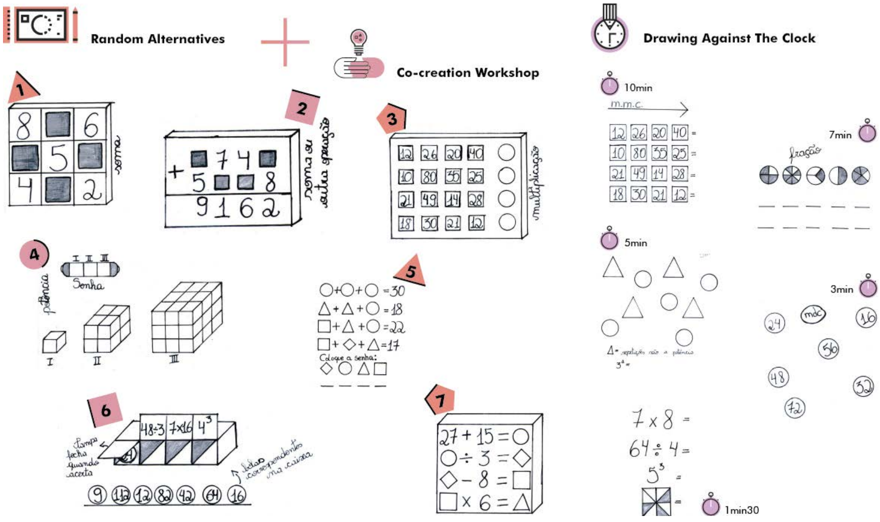

Fig. 20.3 - Stage of idealization

The level design was structured through content organization: separating the areas of knowledge and content axes defined by the BNCC, and the idealization of the challenges present in the game. The stage of idealization brought together creativity tools, such as the co-creation workshop by Vianna (2012), which had the participation of a primary school teacher and two children who presented games and solved some classroom activities. Thus, it serves to define levels of difficulty and progression, selecting and refining sketches to be applied in the level design of the prototype.

The skeleton phase of the project brought the definitions of the previous phases: creativity, organization and structuring of the project. The polishing of the interface and gameplay screens defined the function of each item present in them (icons, buttons, popup, etc.), and the modeling and texture settings were aimed at balancing the performance and content of the game.

The clarity of information to the user was the main focus of the entire interface structure. Buttons and popups with the same function were positioned at the same point on the screen to reinforce the objectivity and understanding of their action. Fig. 20.4 shows the final structure of the prototype after the graphic treatment.

The structure of gameplay took into consideration the immersion of the user. For this, the player's camera is placed in perspective in a "first person" view mode, where the player has complete control over his vision and movement, being free to explore the rooms. For the same reason, it was defined that a threedimensional environment would be a better choice because it facilitates

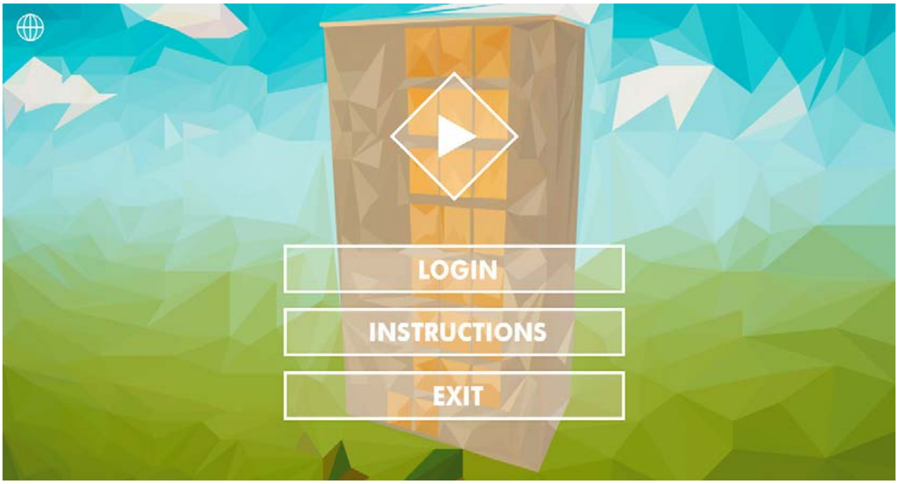

Fig. 20.4 - Home screen of the game

Fig. 20.5 - 3D environment of the game with some challenges

the association of a virtual environment with a physical one, reproducing the vision of the human eye, different from 2D environments, that are frequently used in educational games and identified in some analyzed museums. The execution of this project method resulted in a game prototype planned to support the content present in BNCC for the 6th year of elementary school, reproducing a format that allows the scalability of the game to the other axes and areas of knowledge and/or other years of elementary school.

20.5 Conclusion

This design project fulfilled its requirements, through the design of experience linked to Interaction Design, to connect its target audience and the school environment with the Brazilian education system in a playful way. Based on an analysis of the areas of knowledge and the content axes expected to be implemented in teaching with studies and assistance of professionals related to education and/or children.

The transfer from books to an educational game has made learning less linear and the child more accountable for their learning, reinforcing the reading with positive feedbacks and tips, but without tying the concept only reading-based learning. The rooms, content axes, and challenges were arranged hierarchically, but without requiring the user to follow them by reinforcing that he is an active participant of his learning. All this logic was thought in a scalable way allowing its reproduction for all areas of knowledge and/or school years under the same concept.

The purpose of using experience design as a guiding and methodology base stressed its potential as the main focus for solving problems in this design project. Since the final product became a game, the perspective of game design was brought to the project, which correlates nicely with experience and Interaction Design, where the methodology steps and tools generated requirements, such as: game concept, UI, level design, style and gameplay.

Finally, the impact on the audience size that would be reached was what generated the replacement of a physical museum for a virtual game. It hopes to elucidate the important role of design as a collaborator of a teaching method that is more attractive to its audience, which inspires and encourages children to seek and improve their knowledge.

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21. A Good Procedural Rhetoric for Good Gaming Practices

by Isabella Patti

Abstract

In the wake of recent developments in the field of New Media Studies, Game Studies and Narratology, this essay aims to highlight some of principles useful to recognizing an educational simulation game when it is wellmade. Starting from the assumption that a game is a system based on rules and mechanics, and that their typology makes it more or less effective, more or less engaging and intense, more or less formative, the essay wants to analyze the principles related to content (narration) that are best suited to provide an appropriate simulation learning experience. For these reasons, the research analyzes of a selection of current educational Serious Games and compare their contents with the Procedural Rhetoric Theory (PRT) proposed by the game designer Bogost (2007). This theory identifies in the video game a system of rules and mechanics that is based on the rhetoric linguistic techniques of translated into a computational procedure. According to the PRT, games can exercise a good persuasion provided that the gameplay features a meaningful representation of this underlying procedure. To support these principles conceptually, the essay analyze also the pedagogical side of the contents and present some of the "36 Learning Principles" proposed by Gee (2007) will be used. This model proposes specific characteristics of each learning dimension and contributes to defines the principles of a wellmade learning experience. Considering the Serious Games analyzed through the lens of the PRT and the 36LP, the article aims to identify a series of rhetorical procedural principles relevant to the design of the educational content of a serious game.

Keywords: *Game Studies, New media Studies, Procedural Rhetoric, Game Experience.*

21.1 Serious Game Movement

Confined for decades in the sphere of leisure, simple entertainment or sport, digital games have suffered for decades a real cultural discrimination that has changed only recently. The reasons for this change are essentially two: the exponential growth of the computing capabilities of digital processors and the creation of powerful infrastructures in the sector. The combination of these two data – the technical capabilities with the infrastructural ones (for example, greater speed and data processing power, easy access to the network, an increase in connection methods, the improvement of recreational dives and simulation mechanisms) – have allowed the digital media, and digital games in particular, to present sophisticated and captivating simulations able to involve thousands of people through realtime interaction. It is not important what kind of games they are, be they shooters like Halo or fantasy multiplayer adventures like World of Warcraft or realistic simulations like Flight Simulator, digital games today represent a space of fun, representation, experimentation and innovation without equal.

Only recently the academic reflection has recognized the use of digital games as a powerful tool to support people's learning (Kirriemuir and McFarlane, 2004) and several published studies have shown that these can be more efficient learning methods than traditional ones (Papastergiou, 2009). In fact, although the current number of video games used in education is still limited, it is demonstrated that their application leads to the improvement of knowledge and skills (McCall and Work, 2011).

However, despite they're growing success, the academia is still struggling to accept video games as a cultural form worthy of rigorous study and analysis, and proves unable to fully understand that their project must be accompanied by adequate evaluation of scientific processes, results and contexts involved, and by an adequate methodology dedicated to contents.

There is still a lack of scientific explanations and methodologies on the mechanisms by which the components of the videogame can facilitate behavior change and the formation of people, which further hinders the adoption of video games as educational tools. This also happens because, on a more general level and within academic research, it has been difficult to provide digital culture with a conceptual and theoretical introduction of its innovative methods understood as "models of knowledge" in development (Burdick *et al.*, 2012). In fact, after the publication of the fundamental text The Art of Computer Game Design of Crawford in 1982, the scientific papers on this subject have been published only recently. It is reasonable to think that all these improvements that have characterized the commercial videogame dimension in recent years, can be transferred to "serious" gaming applications, that is to say in those playful products designed for collaborative learning and interactive teaching.

21.2 Serious Game and Rhetorical Speech

The type of videogames considered more suited to stimulate this type of learning are the socalled Serious Games (in Italian, "applied games") in which simulation themes, learning and conveyance of contents foster guided training processes: "*they are antiescapist games that are played to obtain more from real life, unlike those games which are played to escape from it*" (McGonigal, 2011, p. 46). Such games are aimed at "building up the players' competences or conveying a rhetorical message so as to make the players reflect on a particular theme" (Salvador, 2015, p. 864). More precisely, "*an applied game is a game that deals with a complex theme without revealing it, that is to say presenting itself as an ordinary game like any other*" (Maestri, Polsinelli and Sassoon, 2015, p. 68). This type of game stimulates experiences that do not isolate the player in a world of self-referential and gratuitous amusement, but rather fosters "*a shared and, at the same time, significant game experience, which generates satisfaction and knowledge for the players and improves non-linear vision, critical analysis and problem solving*" (McGonigal, 2011).

Serious Game projects can vary a lot from one another in terms of style, graphics, scale, purpose and budget: there are some that are made and tested with a very low budget by independent researchers or game developers, or supported from millionaire investments like World Without Oil whose project involved at least thirty-five designers (including Jane McGonigal), cartoonists and developers, and was presented by ITVS Independent Television Service. Some Serious Games today face such themes as industrial or road safety (S-Drive, Samsung, 2014), solve business problems (Lego Serious Play, Lego, 2000), introduce correct practices and habits as regards the conservation of our planet's resources (Food Force, FAO, 2005), deal with situations and contexts with important socio-political implications such as the Palestinian conflict (Under Siege, Dar al-Fikr, 2005). Definitely the first successful serious game that showed the possibilities of training whit this type of medium is Flight Simulator that is a realistic simulation videogame produced by Microsoft in 1982. Its peculiarity is that it was created as a game for casual players but then it has become a true training tool. Lego Serious Play, instead, has been designed to facilitate communication processes between people working in the same company and it improves creative thinking and strategy in the workplace. In the medical field, one of the most recent projects in this sense is Clinispace, a medical realistic simulation videogame in Real Time 3D that simulates a virtual hospital. It is aimed at medical students, and it allows training in procedures in a virtual hospital. Finally the game Superbetter, designed by game designer Jane McGonigal, is a casual browser game that helps people to overcome physical or mental problems.

Summarizing, a Serious Game is a type of game designed for a serious purpose (and not with a serious theme) where the players have a complex experience through simulation: the players' experience can be interactive or not, realistic or conceptual, digital or analogical and it can change players' attitudes and beliefs, and potentially, it can lead to significant and long-term social changes. Since, as Bogost said, "*video-games are uniquely, consciously, and principally crafted as expressions. As such, they represent excellent candidates for rhetorical speech – persuasion and expression are inexorably linked*", to design a good serious game it is necessary to have the "procedural rhetoric" under control in check (2007, p. 45). By "procedural rhetoric" I mean a new type of persuasive and expressive practice at work in artifacts like Serious game: "*More specifically, procedural rhetoric is the practice of persuading through processes in general and computational processes in particular. Just a verbal rhetoric is useful for both the orator and for the audience, and just a written rhetoric is useful for both the writer and reader, so procedural rhetoric is useful for both the programmer and the user, the game designers and the player. Procedural rhetoric is a technique for making arguments with the computational system and for unpacking computational arguments others have created*" (Bogost, 2007, p. 3).

21.3 A Good Procedural Rhetoric

The question we ask ourselves at this point is what are the signs of recognition of a "successful" educational Serious Game – we say "good". To evaluate the goodness of the game one must start essentially from two factors. First of all, since the games are rules-based systems and as such allow an important and effective feedback mechanism, they are structures that must be optional (the result of a voluntary choice), never coercive and increasingly alternative to reality. More, they must be stimulating paths, with interesting obstacles and feedback systems. As McGonigal claims: "All games (digital and non-digital) share four constants: voluntary participation, feedback system, goals and rules; all the rest is strengthening or improvement of these four central elements" (2011, pp. 404 et seq.).

Based on these four qualities, all video games are made primarily and consciously as expressions and as such, the more they are designed around a solid procedural rhetorical discourse, the more they will be able to engage players, as well as teach them something. In fact, persuasion and expression are inexorably linked in every form of expression that is oral, written or visual.

In a videogame, the procedural rhetoric analyzes the art of persuasion through rules-based representations and interactions rather than spoken or written words, and it focuses on how video game producers develop laws and rules within a game to convey a particular ideology. By "convey an ideology", I mean that representative goals video games pursue related to literature, art and cinema rather than instrumental goals related to utility and instruments (Bogost, 2007, p. 45). Being interactive, videogames require user intervention to complete their procedural representations, and therefore they offer particularly promising opportunities. However, these opportunities are not assured given that "*Interactivity guarantees neither meaningful expression nor meaningful persuasion*" but it sets the stage for both, and for a good gameplay. Indeed, interesting choices do not necessarily entail all possible choices in a given situation; rather, choices are selectively included and excluded in a procedural representation to produce a desired expressive end (Bogost, 2007, p. 46).

Greater interactivity serves to make the gaming experience more engaging, so much so that the goodness of the videogame can be done depends precisely on the "spectrum of vividness" that Bogost theorized. This spectrum "*producing more vivid experience thanks to the player's active involvement, but that vividness comes not from immersion, but from abstraction. The values common to virtual reality and computer graphics assume that the closer we get to real experience, the better. This sentiment corresponds directly to the vividness spectrum, with the best interactivity coming closest to real experience. But meaning in videogames is constructed not through a recreation of the world, but through selectively modeling appropriate elements of that world*" (2007, p. 46).

For this reason, interactivity are not based in the total number and credibility of user actions; rather, the relevance of the interaction in the context of the representational goals of the system is paramount.

21.4 Spectrum of Vividness and Rhetoric Elements

The work of this research is aimed at the project of a serious creative learning game in the context of university education to improve active knowledge acquired through simulated experience. To get an engaging "specter of vividness" and to increase the players' selective interaction, the basic structure of the game (rules and goals) was conceptually supported by the contents of some of the 36LP by Gee (2007), and practically by data collected and analy-

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zed from the students of the Design History course of the University of Florence in the 2015-2018 period). (Fig. 21.1)

The method used is based on a specific initial procedure: the creation of worksheets designed to reconstruct the greatest number of details and contents identified with a design topic / object and to learn in a problematic way (the worksheets presented simple or complex questions on basic, functional, morphological and aesthetic data; the collection and analysis of the data obtained, from which important indications emerged for the videogame to design. For example, how and where the student chose information, why some of those answers were incorrect or incomplete, how a choice was made in front of contradictory data, etc. This was an effort of humanistic investigation: not were the errors corrected, but the reasons for the errors and the type of support used for the study and research were discussed (such as: social media, video, interviews, images, quotes, etc.).

This data was used to present the narration of the game according to principle n. 31 and n. 32 of Gee. The first principle states that: "*Learning is done in such a way that learners come to think consciously and to reflect on some of their cultural models on learning and on themselves as a learner, respecting their identity and abilities or their own social affiliations, and compares them with new learning models and with himself as a learner*" (2007, p. 193). In fact, the system was developed in this direction: the analysis of errors and of different approaches to solve the questions proposed by the worksheets was useful for to hypothesize different types of "identity" of players with characteristics basic specifications. The concept maps, created to address the problems of multiple representation of narration was useful for development of augmented objects. In the end, the verification of the analysis tools to configure the system has defined different levels of knowledge of objects for different groups of students.

The game was designed with the following procedural features.

- **Applied**: it is a "Game aimed at purposes that are not pure entertainment [...] and that comes close to a complex theme without revealing this intention, without presenting itself as a game different from the others" (Maestri, Polsinelli and Sassoon, 2015, p. 68). This applied game is based on principle n.7, Committed Learning, of Gee: "*Those who take part in an extended commitment that constitutes the extension of their identities in the real world into a virtual identity towards which they feel engaged and in a virtual world they find engaging*" (2007, p. 190).

- **Educational**: starting from a generative event, the player's primary interest is focused on the theme of life and choices, and their relationship

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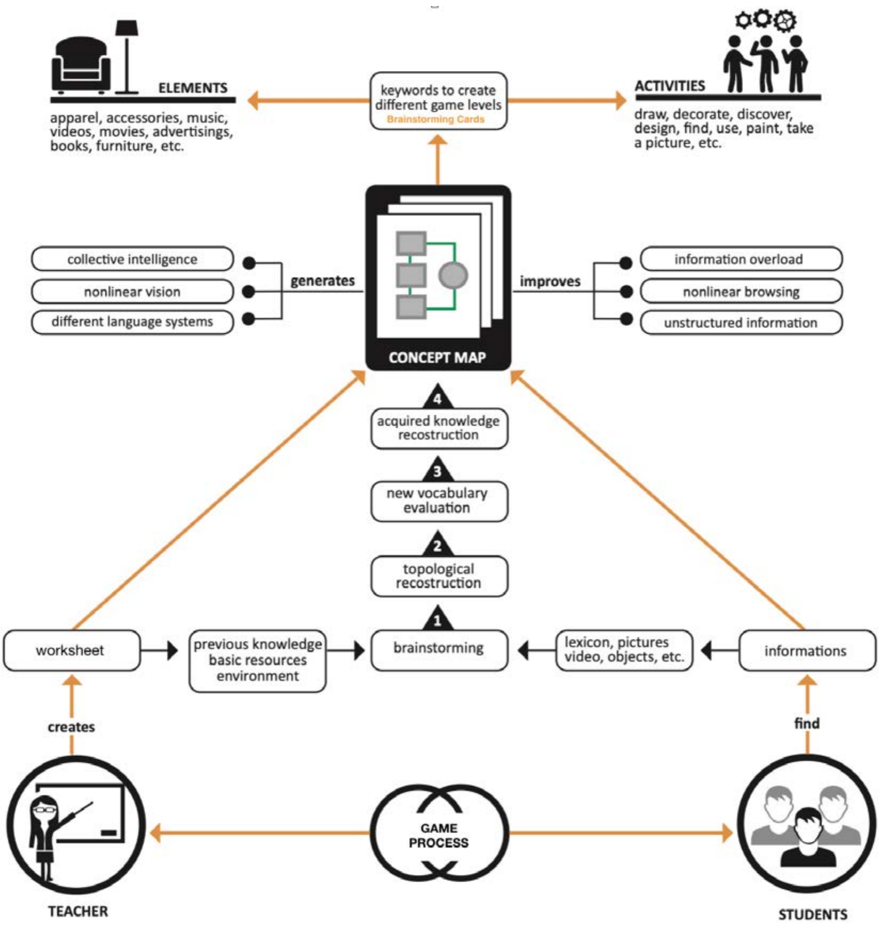

Fig. 21.1 - System of conceptual maps of the game

with the consequent mental state. The flow of events is influenced by the state of the system which includes the previous choices, thus "forming" the player directly on the topic. This creates a direct link between gameplay and learning (Koster, 2004). That is based on playful narrative dissonance (when the playful and narrative purposes come into conflict, etc.), and on the principle n. 21, Material Intelligence, of Gee: "*Thinking, problem solving and knowledge are "stored" in tools, technologies, concrete objects and in the environment. This allows those who are learning to occupy their mind in other matters, combining the results of their own thinking with the knowledge placed in these objects, to achieve even more important effects*" (2007, p. 191).

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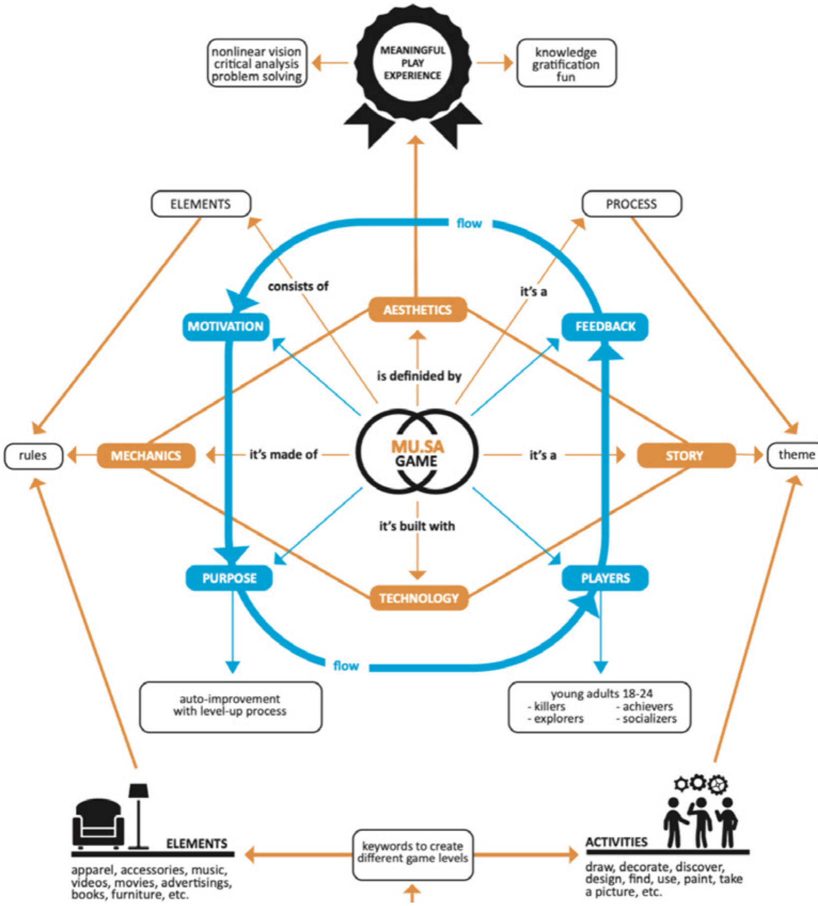

Fig. 21.2 - Game Structure System

- **Motivational**: it provides a motivational theory that the player must be motivated to go through the entire gaming experience and the parallel learning process: in order to enhance motivation it is necessary to choose a particular content, a learning path without steps and not too short, in where interactivity, rhythm, creativity and media integration are treated in detail. The motivation follows principle n. 10, Amplification of the Stimulus, of Gee: "*In the face of a small stimulus, the learner must obtain many effects*" (2007, p. 190).

- **Based on selective interactivity**: the meaning in videogames is "*Constructed not through a recreation of the world, but through selectively*

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modeling appropriate elements of that world" (Bogost, 2007, p. 46) which are presented following the principle n. 27, Explicit Information "On Demand" and "Just in Time", of Gee: "*The learner receives explicit information both on demand and just in time, when he needs it or right at the exact point where the information can be better understood and used in practice*" (2007, p. 192).

- **Based on the anamorphoses**: "*Interactive technique that invites the observer to become an actor and solve the enigma by overcoming the deceptive threshold of representation to access the deception of simulation voluntarily*" (Giuliano in Cambi and Staccioli, 2007, p. 173) and on the principle n.1, Active and Critical Learning of Gee: "*All aspects of a learning environment (including the ways in which the semiotic field is designed and presented) are developed so that they can stimulate not the passive learning, but the critical and non-learning one*" (2007, p. 189).

- **Based on adductive reasoning**: in this case, I mean "adductive" as in Peirce's philosophy that refers to the procedure which consists in advancing an explanatory hypothesis for a certain set of observed facts, and in principle n. 16, Multiple Roads, of Gee: "*There are many ways to make progress and move forward. This allows learners to make choices, to rely on their strengths, on their learning style and to solve problems, but to try alternative ways at the same time*" (2001, p. 191).

Video games offer a particularly valid context for the interactivity that Boost calls "selective" but they are not an educational panacea, nor should they be used for all learning objectives: like all media, they have strengths and weaknesses. If the intention of the designer (s) is to design a game that presents the arguments as a cause-effect relationship based on critical methodologies, that is, on interpretation, serious games are a land of great opportunities.

Notes

[1] Bogost (2007), Jee (2007), Crawford (2003), Juul (2009), Salen and Zimmerman (2004), Shell (2008). The Movement of Serious Games is made up of designers who design games that make the difference in people's lives and considered a means of study and potentially also of social change (M. Andreoletti, 2010).

[2] On the "semiotic field" in principle n.32 of Gee (2007, p. 193).

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22. Learning Through Correlative Understanding

by Sooraj S S

Abstract

Electronics and products are essential to our day to day lives, but how well do we know them? As the access-age to technology is steadily declining, so is our knowledge about the functioning and manufacture of these. This paper aims to understand and create new methods of educating and visualizing complex subject areas such as electronics and repair. These subject areas are mostly dealt with by specific professionals but are key to a sustainable and fulfilling life of the layman. Education in this field helps us understand the value and functioning of objects in our lives and our material connects to them.

The existing methods of education have been ineffective in generating interest or helping users retain the knowledge generated since education in these subjects have been limited to theoretical text and documented practices.

Learners resonate with methods that use the least external inputs and can be quickly picked up and associated with. In Associative learning, alternative methods such as visualizing or experiential learning have been largely undefined and the scope of using these are explored in the paper.

The process of using alternative stimuli like visual memory or muscle memory is the key outcome of the study and the methods mentioned may be used in multiple fields with user discretion. The outcomes were tested out on a limited target audience using sample cards and infographics.

Keywords: *Electronics, Correlation, Repair, Biomimicry, Education, Association.*

22.1 Introduction

Knowledge is passed down across generations through education and various methods are used to communicate these ideas. Since learning something new requires patience, hard work and investment of time, it is essential to create curiosity and engagement within subjects. Traditional trends in education have focused on learning through repetition and hence engagement within subjects is low. Teaching methods in Asian countries like India is driven by textbook style and seldom invoke critical probing abilities. As mentioned by Essay (2018), the traditional method of teaching is when a teacher guides students to understand through memorization and recitation techniques consequently not developing their critical thinking, problem solving and decision-making abilities. This leads to bad retention and low adaptation of knowledge in everyday scenarios. Moreover, the nature of subjects is uninspiring due to the lack of relativity it has to one's everyday surroundings. The common man is disconnected from the origin, production, and the prolongation of technology that they are deemed as alien and avoided. This leads to loss of the necessary skills of understanding, improving which used to help us in the past. This cumulates to a common need for a better way of understanding electronics and improving education.

22.2 Background

The field of electronics deals with consumer goods which help us in our day to day tasks, increase our knowledge and provide entertainment. We have developed machines to accomplish almost any task but the knowledge about these is slowly being restricted to a specific few. The once democratic field of hacking products is restricted by corporates and goods which are of lower quality and are continuously being pushed into the market. All these are going unnoticed because the general user is unaware of the inner functions of his/ her products. In their defense electronics have millions of tiny components and complex connections which make understanding it difficult for even professionals.

As demands for faster, better and more is increasing, companies are taking shortcuts to create products which are easily damaged and cannot be easily repaired. "Electronics and repair is not everyone's cup of tea and is complex and overwhelming"; Or is it? Is it proper methods of understanding that is lacking? Can common users be above corporate agendas for product obsolescence, choose better and demand more. All these depend upon how informed and aware we are about our products. By making electronics accessible and inclusive we can repair, improve and care for them and be free from the clutches of corporate obsolete behaviors.

Currently, the users possesses knowledge about the utility of the object and not functionality (how it operates). The functional knowledge of it is hidden and known by the company and people of specific professions like electronics repairmen.

Electronics being a vast ground can be grouped into categories like heavy machinery, personal use, consumer goods, kitchen items etc. Consumer

electronics have been studied as a part of this study to understand the most prominent products. Amongst the general public there are 3 kinds of users:
1. the users with no understanding of functionality;
2. the users with understanding of functionality but no influence over it;
3. the users who can control functionality by repairing or hacking objects.

General users of products are provided with manuals on how to use them and considerations while doing so. But repair manuals or part/ spare lists are not provided. Combined with the difficulty in finding actual spares makes it difficult for users to understand electronics.

22.3 Inspiration

The Indian economy is a developing one and has been thriving on multiple unorganized job positions. One such posting is that of the local repairman. Every street or town has its go-to kaaregar (fixer), and they help families fix, polish and run electronics for longer. These fixers are sometimes affiliated but mostly are a third party or independent professionals. They are proficient at jugaad and fixing products with minimum spares and maximum efficiency. And as any professional in India functions, they make these users a part of their repair process and involve them in the act of repair. It may be through narrating what went wrong in extravagant detail or by asking the users to go fetch spares themselves. The result is that most often a user can fix a similar complaint if it persists.

The repairman hence spreads on his/ her knowledge to others and builds a network of knowledgeable users. In India, this mode of propagation happens through storytelling or narratives. This study aimed to incorporate such a storytelling methodology to electronic repair. If alien parts could be related and linked to our day to day objects, users can understand it better, visualize it easily and remember it quickly.

This application will help novices in electronics, students or anyone and everyone trying to learn more about their products.

22.4 Methodology

Visualization and Storytelling. The study uses inspiration from storytelling and uses this to create different narratives for products. Storytelling through association makes use of the wide array of visual memories collected from the moment we are born and taps into it according to need. We can relate the form, color or attribute of a given electronics part to things that we already know and recollect the functionality and aesthetics easily, henceforth. This also provides a structure to the information and hence helps in linking and revisiting information.

This is made possible by the advanced and long term visual memory humans possess. It is quicker for our brain to absorb things through visual and tactile memories than from other methods.

As the Chinese proverb goes"I hear and I forget; I see, and I remember". Similarly, Electronics can be made more relatable by creating visual narratives for components through which users can easily identify and maintain their products.

Correlation. Correlation means association; more precisely it is a measure of the extent to which two variables can be related.

We visualize and identify whether two or more objects have properties in common. We have a wide array of visual memory developed from the moment we are born. This existing memory can be related to the newer components in terms of form, color or attribute. And hence we can quickly understand and remember electronic parts. This form of usage helps users understand and remember the appearance and properties of electronic spares. Through this understanding, users can pursue repair or upkeep of their products.

Methods that use multiple senses are essential in education, as this can invoke creative thinking in students. It also helps build a culture of narratives, through which users can overcome the fear of complex electronics and view each one as a story to be understood and solved.

Moreover, it can create subconscious links between things and help in creating a collected web of knowledge. It can expand to multiple fields and change how we see everything in our day to day life and understand it. This exercise also encourages curiosity while linking relevant ideas. Putting a context to content is always important to organize and retain the said content in our memory bank. The key is to establish valid interrelationships and hence provide maximum value by supporting available resources rather than overthrowing them.

One of the major benefits of the method is that the users themselves can choose what field or elements to correlate to and this can be based on interest or prior awareness. This helps in linking disciplines and finding more common ground for development.

Nature of Correlation. In truth, most of the objects and products we use including electronics are largely inspired by plants, animals or natural phenomena. This is because biomimicry in design is largely popular and our solutions are based on existing ones around us. Hence the understanding of tracing back and relating objects help users connect and remember the properties and uses of electronics. Here Animals, birds, daily objects have been connected to electronics-based on based on form, color or properties. These objects are then collectively integrated into a story that is more memorable and hence easily solvable. The intent was to let the user quickly understand and grasp the properties of electronic spares and give them the opportunity or spark an interest in upkeep. As the user begins to see something more than components, wires and functionality they begin to connect to these said "objects" on a deeper level.

Trial Samples. Electronics spares found in day to day objects like computational devices, kitchen appliances and personal care objects were identified and with the help of a small target group related to animals and birds. More trials and correlations are yet to be identified and verified by users.

1. **LED.** Light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it. In nature, there are several organisms which produce its own light, but the most common one is the firefly.
2. **Resistor.** Resistor is an electrical component that reduces the electric current in a circuit and controls the flow of current to specific components. Resistors are identified through the colored bands on them which associates to a certain value of resistance.
   Wasps are insects which have unique stripes on their bellies. They control and restrict the activity of other pests in gardens.
3. **Diode.** Diode is a semiconductor device which allows the flow of current in only one direction. It has low resistance in one direction and a high resistance in the other thereby helping in such a regulation. Many fishes have the property of being able to swim in only one direction; that is forward due to the straight line of force generated by them from backward pressure.
4. **Fuse.** A fuse is an electrical safety device that operates to provide overcurrent protection of an electrical circuit. Under high current, the metal wire in a fuse melts and stops the further flow of high current. Lizards use a similar kind of method to escape threats by cutting off its own tail.
5. **Capacitor.** A capacitor is a device that stores electrical energy in an electric field. Camels store water in their humps and release during need like a capacitor. Here the component and camel relate visually as well.
6. **IC.** An IC is a small wafer, usually made of silicon, that can hold anywhere from hundreds to millions of transistors, resistors, and capacitors. IC's have multiple connection legs similar to insects like spider. Spiders when they reproduce hold many young ones inside the carrying egg like housing different components in an IC.

Fig. 22.1 - Interrelation between electronics and natural components

7. **Buzzer.** A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Buzzers are usually used as confirmation sounds to any activity. Bats similar in form produce sounds similar to buzzers and use these sounds to echolocate itself while flying. These sounds confirm the trajectory of the flight.

22.5 Results

Gamification for Education. Gamification focuses on using the interactive nature of games to create more fun and occupying environment for users in non-game topics. This keeps them motivated to revisit and retain these topics over longer periods.

These games will focus on creating easier, faster and better methods to understand [a] complex subject areas or resolve the subject areas for [b] complex user groups. It provides users the opportunity to derive their understanding and meaning out of topics hence creating unique learning experiences.

They can choose to utilize the methods on different levels and bring in their own set of personal interests to the subject. Hence it helps develop the user in his/her chosen field and the complex subject area. Gamification is also to ensure that we are not limited by technology and can create and explore on more open platforms. Involving variety in the platform ensures that we are more open to ideas and not depended on a particular method to understand. Games also ensure that the player's control the choices that they make; this is a major component in self-learning as it provides multiple paths to solutions rather than a said direction. Open exploration is the essence of higher learning and gamification ensures maximum freedom and opportunities.

Adoption. Users have the liberty to choose how they want to initiate the process of correlation. They can use support systems created by the manufacturers or create their own methods and toolkits. Various functional adoption strategies include, through cards that are handheld and transferable, to stickers on your laptops or backpacks, to textbooks which are curriculum material, to posters in areas of electronic usage and labels for packaging which will be placed or used in coordination.

Cards can be used for general awareness and quick reference. A collective grouping of these cards will help form scenarios through which the entire electronic device can be studied. Stickers are more accessible and invoke curiosity and help the idea spread among peers. Stickers and labels with similar motifs can be widely used to improve popularity and reach a wider range of

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Fig. 22.2 - Card sample 1

Fig. 22.3 - Card sample 2

Fig. 22.4 - Stickers to propagate correlation

Fig. 22.5 - Labelling spares and components

audiences. Textbooks or study material for students can adopt such easier methods of teaching.

Posters can be used in labs, workshops or areas where users deal with common electronics and components.

Labels can be used in the storage and packaging of components so that they can be quickly identified.

A complete story of how the device functions and what are the implications of error in components can thus be created through this.

Sample Story. An attempt to explain a simple household trimmer in the form of a narrative is what follows. In this story components are used as various characters and their connection as the output activity.

"*Long time ago in a pond called trimmer lived several frogs. They were happy and content in their lives. One of these frogs was called switch. During one* *monsoon when the rivers and ponds overfilled, a crocodile called motor came to pond. He begged the frogs to let him stay and the carefree frogs obliged. Soon after several frogs began disappearing one by one. Switch was suspicious and asked his friend LED the firefly, to keep an eye. That night when all the frogs where sleeping Led saw motor sneak out and gulp several frogs. The frightened LED hid himself and waited in silence. Next morning LED informed Switch of the misdeeds motor was doing. "Oh no, but how to stop motor", exclaimed switch. The sad duo thought of all possible ways but were clueless. An elderly Eel called battery passing that way, saw their worries and enquired what happened. After listening to their story battery agreed to help them. That night switch slept next to motor and LED on him. As usual motor woke up in the dark of the night, but LED using his light informed switch and switch jumped up high and cried ON ON ON. Hearing the signal the eel came and bit motor on the legs sending strong shock through him. Motor spun around and around in pain, until he couldn't any more.*

Since that day whenever the crocodile tried to eat any frog he was punished and spun thanks to switch, LED and battery".

22.6 Conclusions

The method provides an open platform for people who want to explore their products.

Understanding and connecting with our products have a major implication over how long we decide to maintain, upgrade, repair and reuse them. We have to keep in check about negative consumerist behaviors by creating better, longer lasting products. This can be done only by democratizing design and upkeep and providing maximum options for these. Manufacturers should showcase complete transparency regarding their products so that users can interact and improve the functionality of their products. They can provide aids such as manuals and spares and also create a stimulating environment in the internals of the products as well. Users must put in an active effort to prolong their usage of a singular product, understand it and connect with it. Being in connect with our material possessions can help avoid overconsumption and help us lead peaceful, less-cluttered lives. Ideas such as open sourcing and participatory design are the future of product design and being in the bandwagon of these will ensure a better user-product scenario. Creating aware and sensible individuals is necessary for developing humans as well as the products we use.

It also allows users who are not necessarily from scientific or professional backgrounds to repair their products and be independent.

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Fig. 22.6 - Info cards which explain the nature of relation

Users who have learning disorders or are slow at learning through traditional methods are benefited from this process while improving their creative abilities.

Stimulating the education method is necessary and important for the growth in focused fields and improving interest among layman. As games include using the creative abilities of our brain, it is helping in improving the user's capabilities of understanding more and doing better.

22.7 Findings and Further Scope

Apart from electronics, there are several other fields in which this method can be utilized to convey the information in a more inclusive, accessible and unique manner.

Each individual's relations are shaped by his/her experiences and are unique to self, Hence giving the possibility to look at one object in infinite possible narratives. This, in turn, adds a scope for customization and personalization which is vanishing from our mass-manufactured products.

Association doesn't necessarily have to be a singular object and even a scenario can be derived from the functioning of an object. Associative understanding and learning opportunities exist in case of any discipline in which involves active user participation and these help users widen the scope and their involvement in the discipline.

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III PART

DESIGN FOR LEARNING

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23. Teaching Universal Design. Human-Centred Process and Methodologies in the PUDCAD Project

by Antonella Serra

23.1 Introduction

The broad perspective with regard to learning, opened by the Conference on "Designing for Inclusive Learning Experience", provides us with a significant opportunity to reflect on the tools, methods and processes used in creating instructional and educational processes that can be targeted on different user categories.

The contributions presented in this volume document the outcomes of experiments, case studies and/or best practices applied to situations of formal learning[1] – in particular in Higher Education – but also to informal[2] and non-formal situations[3]. More specifically, we have examined the relationship between "learning" and "inclusion", developed along lines that differ greatly from one to another: from the ways of including students with disabilities in the scholastic environment and educational activities, to the teaching of Universal Design as a value intrinsic to design itself and not as a sporadic and occasional practice.

Universal Design (UD) is defined by the Center for Universal Design[4] of North Carolina State University (CUD) as "*the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design*" (Connell *et al.*, 1997).

Therefore, it concerns products and environments to be used by people of all ages and abilities/disabilities to the greatest extent possible: a design that respects human diversity and promotes inclusion of all people in all activities of life (Story *et al.*, 1998, p. 2).

The term Universal Design (UD) was coined by Architect Ronald Mace in 1985. He challenged a consolidated design approach that conventionally addressed average users in favour of a design of products and environments more accessible and usable by a larger number of user (Story *et al.*, 1998, p. 2).

In 1997 The Center for Universal Design stated the 7 principles of Universal Design of products and environments (Connell *et al.*, 1997), identified by a name, a definition and guidelines for their application. Tab. 23.1 shows their contents.

Tab. 23.1 - The seven Principles of Universal Design

The seven Principles of Universal Design

1/ Equitable Use

The design is useful and marketable to people with diverse abilities

Guidelines

1a. Provide the same means of use for all users: identical whenever possible; equivalent when not.
1b. Avoid segregating or stigmatizing any users.
1c. Provisions for privacy, security, and safety should be equally available to all users.
1d. Make the design appealing to all users.

2/ Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

Guidelines

2a. Provide choice in methods of use.
2b. Accommodate right- or left-handed access and use.
2c. Facilitate the user's accuracy and precision.
2d. Provide adaptability to the user's pace.

3/ Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Guidelines

3a. Eliminate unnecessary complexity.
3b. Be consistent with user expectations and intuition.
3c. Accommodate a wide range of literacy and language skills.
3d. Arrange information consistent with its importance.
3e. Provide effective prompting and feedback during and after task completion.

4/ Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Guidelines

4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
4b. Provide adequate contrast between essential information and its surroundings.
4c. Maximize "legibility" of essential information.
4d. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
4e. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

5/ Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Guidelines

5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
5b. Provide warnings of hazards and errors.
5c. Provide fail safe features.
5d. Discourage unconscious action in tasks that require vigilance.

6/ Equitable Use

The design can be used efficiently and comfortably and with a minimum of fatigue.

Guidelines
6a. Allow user to maintain a neutral body position.
6b. Use reasonable operating forces.
6c. Minimize repetitive actions.
6d. Minimize sustained physical effort.

7/ 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.

Guidelines
7a. Provide a clear line of sight to important elements for any seated or standing user.
7b. Make reach to all components comfortable for any seated or standing user.
7c. Accommodate variations in hand and grip size.
7d. Provide adequate space for the use of assistive devices or personal assistance.

Burgstahler (2009a, p. 1) says that "*Universal Design is a goal that puts a high value on both diversity and inclusiveness*"; moreover, that creating a product or environment accessible to people with disabilities produces tangible benefits for all the others. Concerning the spread of a culture of inclusion, Story *et al.* (1998, p. 133) stated that one of the best ways to influence the future of our designed world is to educate the next generation of practitioners. Hermann *et al.* (2019) pointed out the need to teach young designers how each project produces an impact, and therefore responsibilities, considering that the designed spaces shape the social interactions of everyday life. They also suggested that educators shall provide tools for a responsible cooperation between designers, potential users and the environment.

This article focuses on the design process and the methodologies used in teaching Universal Design within the "PUDCAD, Practicing Universal Design Principles in Design Education through a CAD-based Game"[5] project, of which the Conference "Designing for Inclusive Learning Experience" was a Multiplier Event.

This is not, however, a detailed description of each teaching experiences, but more a systemic reading of the elements that went into them, useful for constructing of a general overview of the process and a focus on some aspects of teaching practice.

23.2 The PUDCAD Project

The Project "PUDCAD, Practicing Universal Design Principles in Design Education through a CAD-based Game" is being implemented with financing

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by the European Commission through the Erasmus+ Program, which got under way in September 2017 and will conclude in August 2020.

The project involves six universities in and outside Europe: 1. ITU, Istanbul Technical University, Department of Interior Architecture (Istanbul, Turkey), the project leader; 2. TH-OWL University of Applied Sciences and Arts, Department Detmold School of Architecture and Interior Architecture (Detmold, Germany); 3. LAB, Institute of Design and Fine Arts (Lahti, Finland); 4. POLIMI, Politecnico di Milano (Milan, Italy); 5. UNIFI, University of Florence (Florence, Italy); 6. BAU, Bahçeşehir University (Istanbul, Turkey).

Partners of the project are the SERCEV Associations, The Association for Well-being of Children with Cerebral Palsy (Ankara, Turkey) and Ergotherapy, The Occupational Therapy Association of Turkey (Ankara, Turkey).

The purpose of PUDCAD (Fig. 23.1) is to create a stimulating, interactive learning environment that enables students of Design, Architecture and/or Engineering to understand and apply the Principles of Universal Design. The specific tool consists of a CAD-based Game, through which the students are encouraged to deal with issues relative to Inclusion, existing in a game context, which they will resolve positively through application of the Universal Design Principles. The genre of the Game is one of Adventure, based on exploration and puzzle solving. The setting reproduces the spaces, equipment and activities of a high school, attended by adolescents between the ages of 14 and 18, including a number of individuals with disabilities which may be permanent, temporary and/or situational[6].

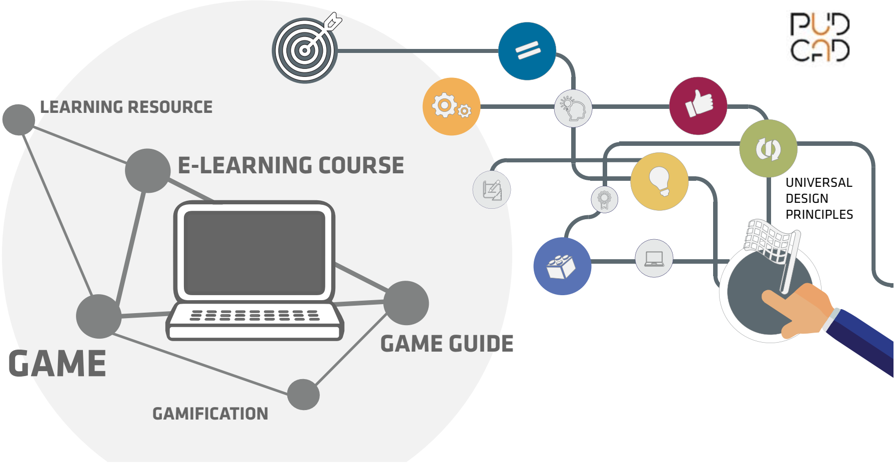

Fig. 23.1 - PUDCAD Project. Graphical summary of design components

The students play individually, taking on one by one the three profiles (characters) envisaged by the game, for each of which they can choose among three different architectural environments. The players move in three-dimensional space, of which they have a view in perspective and a first person camera viewpoint.

This is the first Educational Game developed for teaching the elements of Universal Design at the university level. Its use will be facilitated by a web platform on which material will be at the disposal of both teachers and students, who will be able to make use of them as part of an educational programme or independently.

The skills of the PUDCAD Team are complementary and synergistic with respect to the project goals: ITU, UNIFI, POLIMI and TH-OWL all perform activities of research and education in the sector of Inclusive Design (Universal Design, Design for All and Inclusive Design) and/or assistive technologies; LAB boasts documented experience in the sector of Interior Design and furnishing projects; BAU represents the group of Game Designers on the Team, responsible for development of the Game Software; the SERCEV and ET associations are active in documentation, research and design in the sector of the Inclusion of Persons with Disabilities.

The project is divided into the following parts: (a) didactic activities – workshops; (b) research activities – output; (c) dissemination activities – publications and multiplier events.

The final product is an educational tool designed with the contribution of the users, the students who participate in the various stages of design through project workshops. Thanks to these latter, the educators on the various teams from time to time can fine-tune the process, methods and tools for teaching Universal Design.

23.3 The Instructional Process Developed Through the PUDCAD Workshops

As of this writing, four of the five workshops planned have been held, generally led by a different Activity Leading Organization each time, except for C6 and C7, for which the teaching project was proposed and led by BAU. All the members of the Instruction Team have participated in the implementation of the teaching activities bringing theoretical contributions, reviewing student projects and participating in discussions.

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The workshops lasted 5 days each and involved 25-30 students at a time, 5 for each partner University, selected on the basis of common criteria.

All the workshops were structured as follows.

a. Introduction to the Principles of Universal Design, accompanied by a case history of examples relative to environments, products, interfaces and services.
b. The development of a project activity, related, in each case, to the stage of the PUDCAD project, inclusive of a study phase, followed by a phase of of project development and concluding with a presentation of the results.
c. Lectures also contribute content concerning research, best practices and innovative products.

Fig. 23.2 pinpoints the area around which each didactic experience is developed and the connection among all the activities proposed. The sequence of workshops marks the main stages of the process of development of the Game, which then serve to complete the project activities implemented by the instructors and researchers on the different Teams.

The particular condition created by the project in involving the students both as designers and as end users creates a teaching experience and a User Centred Design (HCD) experience that is particularly intense and authentic for the students, because of the fact that the two profiles coincide.

23.4 Human-Centred Design Approach

The Human-Centred Design (HCD) is the approach within which the main methodologies and the design process model applied to the PUDCAD project are identified. It consists of "*an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance*" (ISO 9241-210, p. VI).

The goal of this approach is the quality of the interaction between people and the systems that they come in to contact with. It uses structured and verifiable methods of investigation and evaluation (Tosi, 2020, p. 3).

Also, PUDCAD project fully applies the Human-Centred Design Principles (ISO 9241-210, p. 5) so:

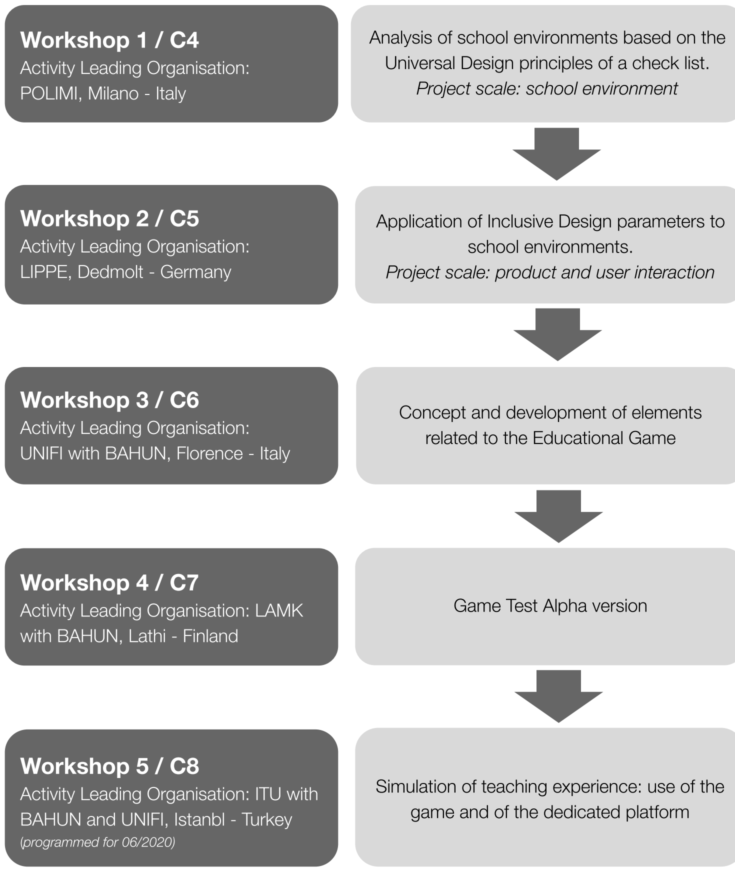

Fig. 23.2 - Student Workshops Sequence and Focuses

a. it is based upon an explicit understanding of users, tasks and context;
b. users are involved in the design and development phases;
c. the project is led and refined through a user-centred evaluation;
d. it is iterative;
e. it addresses the whole User Experience;
f. teams include multidisciplinary skills.

The UCD approach is complementary to existing design methodologies and it integrates with different design and development processes in a way that is appropriate to the specific context (ISO 9241-210, p. 5).

In addition, a Human-Centred Approach is socially sustainable because it "*results in systems, products and services that are better for the health, well-*

being and engagement of their users, including users with disabilities" (*op. cit, p. 19)*. Therefore its application is functional to the achievement of the project's objectives.

23.5 The Design Process

We can summarize the design process of PUDCAD Game (project macro dimension) and the design process of each PUDCAD workshop (project micro dimension) through the four Human-Centred Design Activities (ISO 9241-210, p. 10).

1. understand and specify the context of use;
2. specify user requirements;
3. produce Design solution to meet user requirements;
4. evaluate the designs against requirements.

Fig. 23.3 shows the Human-Centred Design Activities (numbers 1, 2, 3, 4) and their outputs (listed in the boxes below), in relation to Game design and PUDCAD workshops respectively. The diagram also shows the iterativity of Activities 4-2 and 4-3 and the interconnection of the Activities 1 and 2, developed at the same time. In the project macro dimension Student workshops allow the development of contiguous Activities.

In addition, in the PUDCAD project teaching, as well as in other case studies, Human-Centred Design Approach and Methodologies are introduced through specific interpretations: (a) Buratti *et al.* (2018) temporally mark the work phases of W1 indicating the methodology and/or the activity required each day: Empathy Day, Survey Day, Storytelling Day, Ideation Day an Project Day; (b) Hermann *et al.* (2019) illustrate an educational activity starting from the definition of seven parameters for Inclusion (W2); (c) Costa *et al.* (2019) see Empathy as the driving force of the Game production process (W3); (d) in the Conference "Designing for inclusive learning experience" Choi (2019) presents a case study concerning the teaching of Universal Design where the process develops in terms of problem solving.

23.6 HCD Methodologies and Outputs

The following paragraphs illustrate the human-centred methodologies employed in the PUDCAD Student Workshops (Tab. 23.2) in connection with each HCD Activity and their respective Outputs.

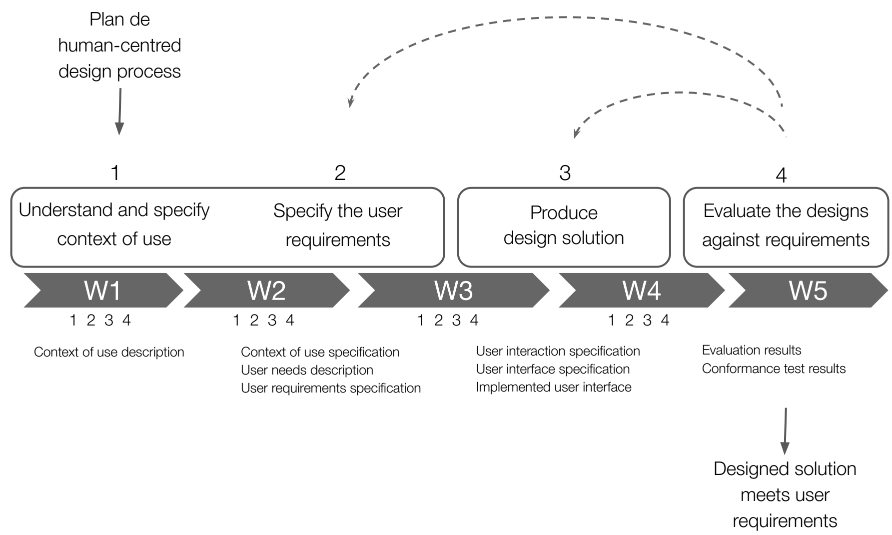

Fig. 23.3 - The Human-centred design process. Revised by ISO 9241-210

Tab. 23.2 - Human-centred design methods employed in the PUDCAD Student Workshops. (Maguire, 2001)

Understand and specify the context of use	Specify user requirements	Produce Design solution to meet user requirements	Evaluate the designs against requirements
Identify stakeholders Context of use analysis Field study/user observation	User requirements Interview Focus groups Scenarios of use Personas	Brainstorming Storyboarding Paper prototyping Software prototyping	Participatory evaluation Satisfaction questionnaires Post-experience interviews

23.6.1 Fist and Second Activities. Understanding and Specifying the Context of Use and User Requirements

During the W1 students analyzed the school environments of 5 Secondary Schools in Milan using a **Checklist** reviewed by POLIMI and based on the ADA Checklist for Existing Facilities[5] produced by the Institute for Human Centered Design[7] (Boston, USA). It aimed to verify the existence of physical barriers in the buildings. This is an internationally recognized Checklist, developed by a le-

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ading Institute in the global promotion of Universal Design and Inclusive Design It was chosen as a way to overcome the lack of common standards between the countries involved in the project. The ADA Checklist[8] is free for download and has a user-friendly and editable format.

The casuistry of the buildings chosen for the analysis took into account the type of school, construction period and urban location. The analysis involved the following functional areas of the building: entrance and common areas, classrooms, labs, toilet rooms, library, gymnasium, canteen, conference room.

The PUDCAD Checklist (Fig, 23.4) has been simplified from the original and now includes a control list with some images as example, a space for notes and some suggestion on how to conduct the analysis. The checklist allowed students to conduct a detailed and objective analysis, which fully meets the requirements and that can be easily done in only one inspection, no matter how deep student observation skills are or the student background knowledge.

During W1 and W2 the different Teams used this same checklist to conduct the analysis in the schools of their own territories, namely Italy, Germany, Finland and Turkey. Methodologies and/or techniques like **Direct Observation** (Fig. 23.5), **User Trials** (Fig. 23.6) and **Thinking Aloud** were also applied to investigate the interaction between users and context. The results have been used to: (A) define the characteristics of Secondary Schools users; (B) to define game scenarios and Game characters.

Empathy Trial. During W1 and W2 students were involved in an Empathy Trial test (Fig. 23.7, 23.8), where physical impairment (W1 and W2) and sensorial

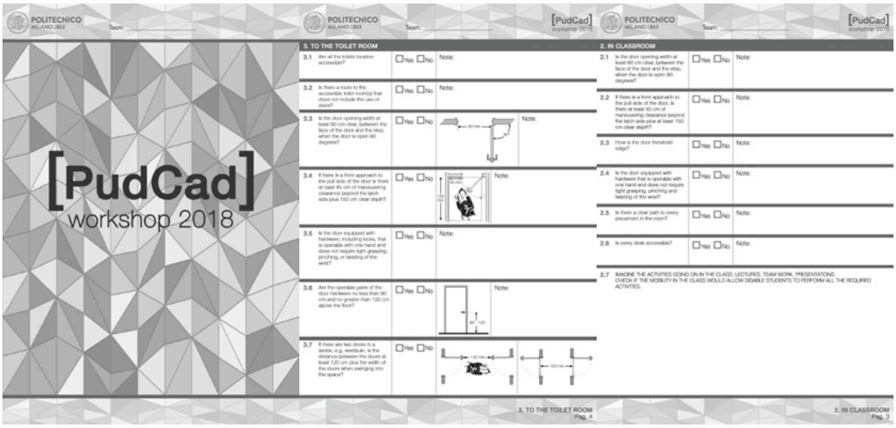
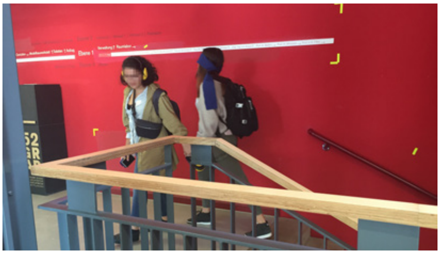


Fig. 23.4 - W1. The PUDCAD Checklist

impairment (W2) were simulated within the project environment, empathizing with the user's condition and interacting with other people and the environment. A study by Teding van Berkhout and Malouff (2015) confirms the value of empathy training in obtaining prosocial results, especially when applied to Higher Education, and its emotional effectiveness: understanding other people's emotions and verbalization of what they experienced.

Additionally, during W2 and W3 students had the opportunity to listen to users with impairments' experience[9], who described their needs and expectations related to specific situations and contexts. Within a positive dialogue environment, students asked questions to further understand what they had listened and to capture contents for their project **(Interviews)**.


Figs. 23.5, 23.6 - Analysis of School environments by UNIFI. Direct observation and User Trial

Figs. 23.7, 23.8 - W2. Empathy Trial

23.6.2 Third Activity. Producing design solutions

W3 workshop was dedicated to develop stories for the Game and to define characters' profiles.

Students chose one theme among those proposed by teachers and then developed seven game stories using Storytelling (one story per each group of students). **Storytelling** (Fig. 23.9) was a precious tool to elaborate: (a) the

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meaning of the game; (b) some essential parts of the story; (c) the identification experience; (d) participants' engagement and (e) the feeling of game/story development (Maestri, Polsinelli, Sassoon, 2015).

The semantic structures and temporal ordering of information in the Storytelling (Gerrig, 1993) aids in inquiry, decision-making and learning (Andrews *et al.*, 2009). This same method was used by the students also in the workshop W1 to describe the difficulties encountered in the analysed school environments from the students with disabilities' point of view.

The methodology of defining **Personas** was used in all workshop. Using a name, a personality and an picture (Maguire, 2001), it helped to describe the needs of single users, in particular those with permanent, temporary or situational impairments (Fig. 23.10). Personas are a powerful design tool with which to build scenarios and collect data (Grudin *et al.*, 2002).

Figs. 23.9, 23.10 - W3 and W4. Storytelling and Personas

Key project steps were accompanied by **focus groups** which involved students and teachers, through informal discussions (Beck *et al.*, 1986) in small groups (5-7 students) or in groups extended to all participants (Fig. 23.11). A focus group generally "*involves one or more group discussions, in which participants focus collectively upon a topic selected by the researcher, and presented to them (most commonly) as a set of questions, although sometimes as a film, a vignette, a set of advertisements, cards to sort, or a "game" to play*" (Wilkinson,1998). "*The general idea is that each participant can act to stimulate ideas in the other people present and that, through a discussion process, a broader collective vision of the individual parts is established*" (Mcguire, 2001). These discussions leveraged the different configurations of classrooms, which changed according to the type of activity (W1, W2, W3, W4). By doing so it was possible to facilitate both dialogue and discussion sessions and project development sessions.

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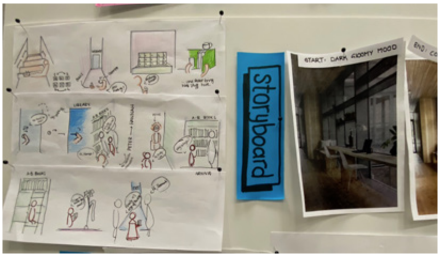
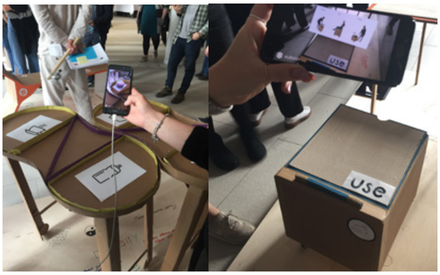
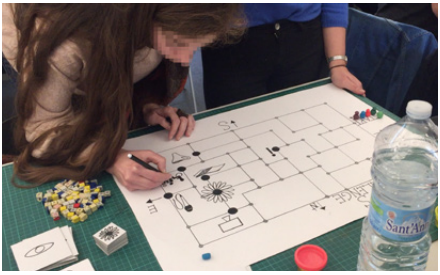


Figs. 23.11, 23.12 - W4. Focus group and Storyboard





Figs. 23.13, 23.14 - W2 and W3. Prototypes

By "Building Scenario" we mean the development of a number of alternative fictional representations - stories - involving specific characters, events, products and environments that give us the chance to explore ideas or product issues in the context of a realistic future (Suri, 2000). In W2 and W3 workshops students created **Storyboards** or "Presentation Scenarios" (Nielsen, 1991) to propose game development hypothesis, using game screen types, controls, time sequences, scenarios and settings, characters, etc. (Fig. 23.12). The Storyboards were presented and discussed with the other students and teachers, regarding positive aspects/critical issues and whether the game was in line with usability criteria.

The W2 and W3 workshops involved the creation of a 1:1 scale **prototype** (Figs. 23.13, 23.14). In the first case (W2), the prototype related to inclusive furniture products to be placed in an area of the Campus that hosted the workshop; in the second case (W3) students had to design board games, so to develop the Game design ideas in an analogical form. The full-scale size of the prototype and the designer coinciding with the user as mentioned before, helped to evaluate huge number of design variables: the dimensional ratio, the ergonomic ratio and the user-product usability ratio. Prototyping began in the

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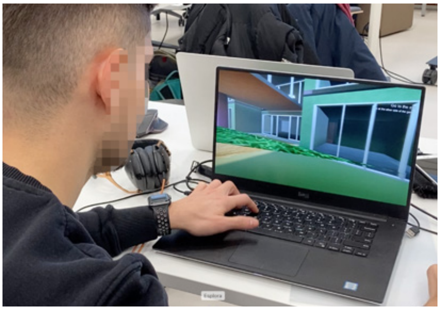
conception phase, through an iterative generation of artefacts (Hasso Plattner Institute of Design at Stanford, 2010) that gave value to learning in an experiential form.

23.6.3 Fourth Activity. Evaluating the Design

The W4 was dedicated to **testing** the Alpha version of the Game and to any corrections and additions (Figs. 23.15, 23.16). This was the most important testing phase on the Game as it could involve a significant number of users (30) and was carried out at a stage where changing the software did not waste too much resources (ISO 9241-210, 2010, p.17). A **Participatory Evaluation** (Mcguire, 2001, p. 616) was carried out individually or with maximum two students per computer. The observations were recorded through a questionnaire with open questions submitted after playing the game. Additionally, a small number of individual usability tests were recorded and the session was followed by a focus group.




Figs. 23.15, 23.16 - W4. Testing the Alpha version of the game

23.7 Conclusion

At present the project workshops have involved about 120-150 students attending Higher Education Design courses located in the four partner countries: Turkey, Germany, Finland and Italy.

Students: (a) have been introduced to the Universal Design approach, (b) have demonstrated to understand its importance in terms of sustainability of the project and social inclusion and (c) have applied it in design practice within the different contexts and project scales.

At the end of each Student Workshop, when their teachers asked to provide an oral feedback on the experience, students confirmed that they considered Universal Design to be essential for the development of a conscious and effective approach to design in terms of sustainability and social inclusion.

Additionally, students showed the adoption of a broader and less stigmatizing concept of disability as disability is seen as a status that can potentially affect all users who experience motor, sensory or cognitive difficulties, either permanently or temporarily.

Following are some observations detected in teaching practice.

Context analysis/Checklist. This tool proved to be very effective, as students could conduct a precise and objective analysis of the spaces. It is complete in relation to teachers' requests and easily manageable in a single inspection, no matter what student's observation skills or previous knowledge are.

The result of the application of this type of instrument is a "guided" context analysis that stimulates in students (a) the ability to observe, (b) to obtain data from the context, (c) to cooperate in a team.

When students conducted the context analysis the in a freer form (W2), a greater production of selective/partial and/or subjective data[10] was evident, although the context analysis factors[11] had been previously shared and discussed with them.

User Requirements/Interview. During the meetings with the users - in some cases made up of people with disabilities, in other cases of the same students - there were difficulties for the students to ask questions (Interviews) and/or to conduct effective direct observations, from which to deduce data relevant to their project activity. These difficulties can have strongly negative repercussions since it has been shown that insufficient effort in establish user requirements is a reason for project failure (Mcguire, 2001, p. 598). Therefore, it is necessary to better prepare students for meetings with users, which in most cases represent unique and non-repeatable meetings, also by planning preparatory activities such as simulations of the same meetings and interviews with the help of other students or the teacher, from which feedback can be received.

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Notes

[1] Learning that occurs in an organised and structured environment (e.g. in an educational or professional training institution or on the job) and is explicitly designated as learning (in terms of objectives, time or resources). Formal learning is intentional from the learner's point of view. It typically leads to validation and certification (Cedefop, 2009, p. 73).

[2] Learning resulting from daily activities related to work, family or leisure. It is not organised or structured in terms of objectives, time or learning support. Informal learning is mostly unintentional from the learner's perspective. (Cedefop, 2009, p. 74)

[3] Learning which is embedded in planned activities not always explicitly designated as learning (in terms of learning objectives, learning time or learning support), but which contain an important learning element. Non-formal learning is intentional from the learner's point of view (Cedefop, 2009, p. 75).

[4] CUD – The Center for Universal Design, web page available at https://projects.ncsu.edu/ncsu/design/cud/index.htm .

[5] A short presentation of the project can be seen on the UNIFI website: www.dida.unifi.it/vp-761-pudcad.html; from this page you can also access other resources.

[6] Inside the Microsoft toolkit "Inclusive101", p. 42, there is an example diagram of the Spectrum Person, available at the link www.microsoft.com/design/inclusive/).

[7] Institute for Human Centered Design, Boston www.humancentereddesign.org.

[8] www.adachecklist.org/checklist.html.

[9] ATISB – Associazione Toscana Idrocefalo e Spina Bifida, www.atisb.it/associazione/.

[10] For the difference between "objective data" and "subjective data" see Boscarol M. (2004) at link: www.usabile.it/262004.htm.

[11] See "Context-of-use factors", Mcguire, 2001, p. 595.

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24. Introducing Universal and Assistive Design Concepts in an Undergraduate Lecture Course

by Young Mi Choi

Abstract

The aim of this paper is to describe approaches for introducing undergraduate students in both design and engineering to the concepts of Universal Design (UD) and to the design of Assistive Technology (AT) devices. A design project undertaken in an introductory class in Human Factors and Ergonomics is presented. A total of 104 students completed a survey at the end of the project self-reporting what they learned.

The results indicated that students learned a lot, particularly from interactions with users, and expect to use what they learned in future professional contexts.

Keywords: *Education, Universal Design, Assistive Technology.*

24.1 Background

One of the challenges instructors face in the field of Industrial Design, Product Design and even engineering is training students how to identify problems and opportunities. The process of problem solving, coming up with a solution to a problem which has already been defined, is already familiar since it is an exercise that most students have done for most of their academic lives. Finding and solving problems involve four general stages: Gap Identification/ Problem Recognition, Problem Diagnosis/Formulation, Alternatives Generation, and Alternatives Selection (Mintzberg, Raisinghani and Théorêt, 1976). Problem Recognition is realizing that an issue exists. Problem Diagnosis involves gathering information relevant to the issue in order to more specifically define it. Alternatives Generation involves using the gathered data to come up with possible ways to get from the current state to the desired state. Alternatives Selection involves picking the solution that is the best resolution for the issue based on everything known about the problem.

In a world with complex and interrelated problems, Problem Recognition which also might be called identifying design opportunities is an increasingly important skill for both designers and engineers. This is especially true for those aspiring to be entrepreneurs or leaders in a particular discipline. Companies devote significant resources to the development of new products every year (Ehrlich and Rohn, 1994; Donahue, Weinschenk and Nowicki, 1999; Krantz, 2012) with development and testing using up to 54 % of the total (Cooper, 1988). It is important to both identify new product and feature ideas that are viable. With problems that cross disciplinary boundaries, there is a need to effectively mix engineering approaches to generate technical solutions along with creative and user focused approaches more commonly associated with industrial design (Grasso and Martinelli, 2010).

The aim of this paper is to describe approaches for introducing undergraduate students in both design and engineering to the concepts of Universal Design (UD) and to the design of Assistive Technology (AT) devices. Universal Design here is defined as the design of environments and products to be usable by all people to the greatest extent possible so that adaptations without the need for adaptation or specialized design (CUD, 1997). Though the goal of UD is to help ensure that more people will be able to effectively use and benefit from a product, many schools in the United States have been slow to adopt Universal Design. The number of people who are expected to have some level of limited ability is forecast to increase (Fletcher *et al.*, 2015) which increases the importance of considering a wider range of abilities when designing products.

Introducing students to the design of assistive products is similarly important. Assistive technology here is defined as any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of people with disabilities. AT is distinct from UD in that the objective is to improve a specific functional ability rather than to achieve broad, general usability.

An early introduction and chance to gain practical experience with both Universal Design and Assistive Design is important. With an early introduction to these concepts, students will have the opportunity to apply their experience to both future projects during their training and into their professional careers (whether product design or other fields).

24.2 Method

The introduction to UD and AT design was performed in a class called Human Factors in Design. It is a lecture based class which provides an introduction to the subject of Human Factors and Ergonomics and related tools as they are used within design. It is a required course for undergraduates pursuing a major or minor degree in industrial design. The students who take the class pursue a wide variety of subjects. About half of the class are industrial design students while the other half are students from engineering disciplines (mechanical engineering, electrical and computer engineering, biomedical engineering, physics and computer science).

Students were assigned a team project (performed in groups of 3) to design an Android or iOS based smartphone application to aid blind and vision limited users in performing a given task. Each team picked from one of the following scenarios.

- Design an application that allows blind and vision limited users to enter an address and navigate/guide them to the destination. Among other issues, the application should consider how addresses are entered, feedback/alerts for guidance (audio, haptic, etc), integration of information such as public transit and street/building level data.
- Design an application that assists blind and vision limited users in identifying everyday items. This may include things like money, price tag information or description of other objects identified in the environment. It may also include things such as integration of QR code identification or local information provided by wireless beacons or similar technologies.

Each team had to choose one scenario to design for at the outset of the project and focus on it. In all cases, there already exist one or more applications in one form or another that provide some level of functionality. The goal of each team was to identify existing applications, document the kinds of functionality they currently provide, identify shortcomings based on Human Factors principles that are barriers to usability or ability to effectively perform the task, and finally to propose an updated design that both enhances functionality and solves existing Human Factors related problems. The end result should be an application design that makes performing the task more effective, efficient and/or satisfying.

The teams were also instructed to consider barriers/challenges presented by the capabilities and usability of the hardware. This is why each team had to pick a platform (iOS or Android) and reference hardware at the beginning of the project and stick with it. For example, most smartphones are primarily or exclusively touchscreen driven which can be a challenge for a blind or visually impaired user. Teams needed to investigate the built in features (audio navigation, tactile feedback, etc) to identify possible improvements to the underlying platform that could help improve the hardware itself (by making it more accessible) as well as improving the functionality of their application.

Within the chosen scenario, each team was required identify a problem/barrier and then to design a working solution to eliminate or reduce it. The teams had to research the scenario, identify realistic barriers, formally define the design problem and success criteria that a successful solution must fulfil, and finally design and test a solution. Teams were encouraged to use a variety of methods to try to place themselves into the shoes of end users performing the tasks, ranging from attempting to simulate a user's condition to engaging potential users through observations and interviews.

The entire project lasted for a total of 5 weeks in the last half of the semester. At the end of the project, the final designs were presented to a panel consisting of usability professionals, assistive technology designers and users with limited vision. Each student was also asked to complete a self-evaluation survey about the project. Completing the survey was voluntary and in no way impacted the score. Participation was anonymous. To ensure this and that the instructor would not know who may or may not have participated all surveys were gathered by a third party and held in an administration office until the final grades for the semester were released.

24.3 Results

A total of 104 students divided across three sections of the class were given the opportunity to complete a post project survey. The responses for each question are shown in this section.

Questionaire

1. **What is your major?**

Major	**n**
Industrial Design	32
Mechanical Engineering	27
Bio-medical Engineering	16
Computer Science	3
Aerospace Engineering	2
Music Technology	1
Business Administration	2
Physics	1
Industrial Engineering	1
Chemistry/Chemical Engineering	2

2. If you have a minor, what is it?

Minor	**n**
Industrial Design	56
Computer Science	4
Aerospace	1
Foreign language	4
Music Tech	1
Public Policy	1
International Affairs	1

3. Have you ever temporarily lost your vision (such as from an injury)?

Yes	15
No	74

4. Have you ever known a close friend or family who has permanently lost their vision?

Yes	13
No	76

5. Have you ever had to provide care for someone who has permanently lost their vision?

Yes	4
No	85

6. Did you use any device or apparatus to simulate low vision during project?

Yes	53
No	36

7. If yes, did you find that the simulation was an accurate representation of the condition?

Yes	30
No	33

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8. Did you meet with blind/low vision users at any time during the course of the project?

Yes	51
No	38

9. If you did meet with blind/low vision users during the project, when did you meet them? (Check all that apply)

a) At the beginning of the project before starting design to gather needs	74
b) To gather input after developing a prototype design	26
c) To test the final design (for functionality and performance)	20
d) no answer given	36

10. Did you test your design with other users (i.e. not blind/low vision)?

Yes	69
No	17

11. What did you learn about the design of your product based on user feedback?

a) A lot. I was able to find many design problems that I wouldn't have known otherwise	35
b) Some. I was able to find some useful design problems that I wouldn't have known otherwise	52
c) Nothing. I did not learn about any new design problems from the users	2

12. How likely are you to consider needs of users with vision limitations in future professional contexts?

a) Very likely	51
b) Somewhat likely	36
c) Neither likely nor unlikely	1
d) Somewhat unlikely	0
e) Very unlikely	1

24.4 Discussion

This project was performed by students in the class Human Factors in Design in the spring 2018 semester. It consisted of 104 total students divided between three sections (A, M1 and M2). Two sections (section A and M1) met at the same time effectively making it a single class. The M2 class met at a different time. The sections were split this way to allow students majoring in Industrial Design to register separately from students pursuing a minor in Industrial Design (ID). The course is re-quired for all students to achieve either a major or minor in ID. The students were divided between sections as follows:

20 students were in the A section (for ID majors)
46 students were in the M1 section (for ID minors)
38 students were in the M2 section (for ID minors)
Total = 104

A project with similar goals (to introduce UD and AT deign methods) to undergraduates was performed in previous years. For this iteration of the project, there were a few differences/changes. The project described in this paper was lecture based, not studio based. In previous years, it had been performed within the second semester of a sophomore industrial design studio class. The major difference to the students is that class times were shorter (a 1.5 hour lecture class 2 times per week vs a 4 hour studio class 3 times per week). The main focus in a studio class environment is to deliver lessons/concepts through the project. In stead of lectures, students spend studio time focused on project work under the guidance of instructors. In the lecture class environment, class time is spent delivering lessons/concepts in the format of lectures and related activities. Students spent time outside of class working on the project to apply Human Factors concepts to the project.

In the studio environment, one focus of the project was to provide direct in depth instruction on the use an application of design methodology (such as Universal Design). In the lecture class, the focus was on delivering a survey of Human Factors and Ergonomics knowledge and tools. Design methods (i.e. user centered design) instruction was indirect. The students' goal was to apply their Human Factors knowledge to the design. However, the project was setup so that it could only be successfully completed if done in a user centered way. Students were given a design scenario, not a specific problem. It was up to each student team to investigate (through research, user input, etc.) to identify a specific, valid problem, define the necessary success criteria a solution must meet, and then design/test a solution to it.

One of the advantages of conducting the project in the Human Factors in design lecture class was the opportunity to expose a larger group of students to user centered design. The class included students with a wide range of majors, some of which may not typically get any kind of exposure to user centered/Universal Design.

As an introduction to universal and assistive design, the project as delivered in this class was considered a success.

- Most students (89/104) across the three sections responded to the survey.

- Vision loss/low vision was an unfamiliar topic for most students. They would have no prior experience or bias based on personal experience for identifying problems that need to be solved for this user group. They would also be starting from scratch in working out how solutions to an identified problem might be approached:
  - most students did not have any prior experience with either personally losing their vision temporarily (15/89);
  - only 13/89 students have known someone with permanent vision loss;
  - only 4/89 have experienced caring for someone who has lost/reduced vision.

- Most students (74/89) sought out users at the beginning of their projects in order to gather and understand needs.

- Most students did NOT engage users after initial requirements gathering.
  - Only 26/89 got additional input during the development process.
  - Only 20/89 engaged users at the end to validate the effectiveness of their solutions.

- Most students (69/86) DID engage other non blind/low vision users during their project to test their designs.

- A majority (53/86) of the teams attempted to employ some sort of simulation of a blind/low vision condition:
  - 30 students indicated that the simulation they used WAS an accurate representation of the condition for their testing:
  - 33 students indicated that the simulation was NOT an accurate representation of the condition for testing.

- As simulations are never fully accurate (and can be very misleading at times), it is unlikely that the teams that though that their simulation was accurate validated their findings/assumptions with actual users. Since a minority of students actually tested their final designs with users, they would never be aware of these inaccuracies.

- Almost all students indicated that they learned a lot or at least some things from their interactions with users that they would not have known about otherwise:
  - 35/89 indicated that they found many problems through user interaction;
  - 52/89 indicated that they found some problems through user interaction;
  - 2/89 indicated that they didn't learn anything new through user interaction.

One of the key metrics of interest from the survey is whether the students were likely to include users in professional contexts in the future. Most were likely (51) or somewhat likely (36). For students who are design majors, this kind of result would be expected since a large part of their training is centered around consideration of user needs and requirements. This is not necessarily a main focus, particularly early on, of engineering training that is focused on building specific technical knowledge and skills.

Enhancements to future versions of the survey should include a couple of openended questions. First if students answer that they are somewhat or very unlikely to include users in their future design work, it would be important to know why. While the goal of introducing the importance of user centered design seems to have largely been met, it is important to find out more about cases where students do not feel it would be important to them.

Acknowledgements

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25. Ergonomics in Design. Then, Now and Tomorrow. Case M19 Campus

by Timo Sulkamo

Abstract

Ergonomics has been part of design and architecture for centuries, since Vitruvius, who lived 1st century B.C. Rome, or Dionysius who lived during the Middle Ages, to Le Corbusier and his Modulor Man in the modern times (Panero, 1979). But they did not call it Ergonomics. The term Ergonomics derives from greek words ergon (work) and nomos (principle or law) (Jastrzębowski, 2012). It was first used in 1857. Like the etymology of the word tells us, Ergonomics is mostly about work, and how we humans do work. The golden age of Ergonomics happened after World War II, when the United States started to pay attention to Ergonomics in their working environments, but there it was called “Human Factors Engineering”.

There is not just one field of Ergonomics. Ergonomics can be divided into different fields depending on the point of view: physical Ergonomics, psychological Ergonomics, information Ergonomics and cognitive Ergonomics, which we today call usability (Launis and Lehtelä, 2018). Because we mostly sit while we work, Ergonomics is mostly associated in sitting and especially chairs. Of course Ergonomics is much more than that. Today we need to pay attention to not just way we sit, but also to the way a place meant for working is lit, and how the acoustics of the space work.

But work is changing, and should the rules of Ergonomics also change? Today people do not just work in a factory or in an office, people can work from almost where ever they want. Remote work is becoming the new norm (Stevens, 2019). Also the equipment for working is changing rapidly. A person can do their work with a cell phone, never leaving their home. How will this change how think about Ergonomics and how we design spaces and furniture?

The interior architecture and furniture design students of Lahti Institute of Design made new designs for their new working areas at their just opened new campus. Their main focus in their design work was “how will they work as designers in the near future”. The new design works combine knowledge from the past, and ideas for the future, with Ergonomics always in mind.

This paper is about an Ergonomics based design course for the interior architecture and furniture design students of Lahti University of Applied Sciences, Institute of Design.

Keywords: *Ergonomics, Human Factors, Work, Learning Environmen.*

25.1 The Task with Some History of Ergonomics

The design task for the 2nd year interior architecture and furniture design students of Lahti Institute of Design of their Ergonomics and Accessibility course was to redesign a large project space of our new campus. The space itself is 41,4 meters x 14,5 meters, and the hight of the space is over 5 meters (Fig. 25.1). But unfortunately the space is not a functional working area for the design students at the moment. It is too open, messy and poorly planned from acoustic point of view (Figs. 25.2-25.3). But before the students started their design work, they had to learn about the history of Ergonomics. They started their history part with basic knowledge about Vitruvius and Dionysius and gradually moved to the modern times and Le Corbusier, then to the golden age of "Human Factors Engineering" in the post World War II United States. They also looked into more creative ways of thinking about Ergonomics, like Peter Obsvik's designs, and also some contemporary examples of the theme, like Geoffrey Pascal's playful furniture for more relaxed working, or Space10 lab of IKEA and it's experimental ideas of the future of work and Ergonomics. For "homework" the students had to read two classics about Ergonomics: Human Dimension and Interior Space by Julius Panero and Martin Zelnik, and a Finnish book about the subject Ergonomia by Martti Launis and Jouni Lehtelä. For research they also used the Humanscale Manuals by Henry Dreyfuss Associates (Diffrient and Tilley, 2017).

25.2 Not Just About Sitting

During the course the students did not learn only about the basic ideas about Ergonomics, because Ergonomics is much more than that. Ergonomics can be divided into different fields depending on the point of view: physical Ergonomics, psychological Ergonomics, information Ergonomics and cognitive Ergonomics, which we today call usability. Because we mostly sit while we work, Ergonomics is mostly associatedin sitting and especially chairs. Of couse Ergonomics is much more than that. Today we need to pay attention to not just way we sit, but also to the way a place meant for working is lit, and how the acoustics of the space work. That is why they also studied about acoustics and lighting design. They also learned about accessibility of interior spaces through the Finnish rules and regulations, and also by doing an accessibility survey at our new campus.

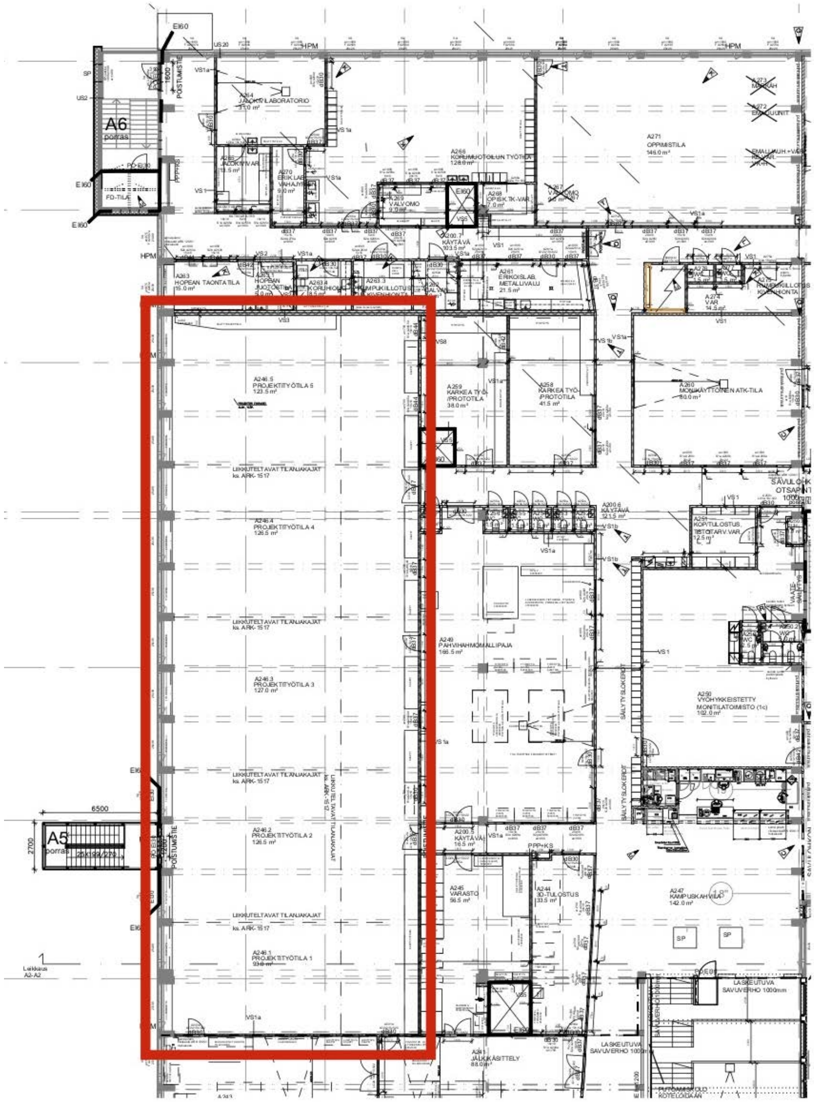

Fig. 25.1 - Floor plan of the large project space of the design task (Sulkamo T.)

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Fig. 25.2 - Messy and unorganised spaces (Sulkamo T.)

Fig. 25.3 - The space has room dividers, but acoustically they are inadequate (Sulkamo T.)

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25.3 The Design Process

For the design process the students used the so called double diamond design process model. So the students started their actual design work by doing surveys, interviews and questionnaires for the users of the space, who are of course the design students, but also the staff of the university. They wanted to find out, how the users feel about the current project space, what works in the space and especially what does not work. Most users felt the space was too noisy and "chaotic", and that it had insufficient lighting and acoustic solutions. With this user-centred approach the had all the necessary information to start designing the space.

The actual design work was separated into two phases: idea phase and final design phase. For the information gathering and sketching (idea phase) the students spent a month, and when the ideas were approved by the professors they spent the next month finalising their design works (final design phase), which included floor plans, sections, fixed furniture plans, detail drawings and 3D renderings.

25.4 The Result of the Design Task

All the professors felt that the final design proposals were excellent, especially for 2nd year students. Every design team designed the whole interior of the space, and also at least one fixed furniture for that interior. Each team separated the large space into smaller sections, to help the acoustics of the space, and also to add more different functions for the space, like lecturing, working, having a break, eating, watching a movie, reading, etc. One team decided to include a design book library to one side of the space, and a material library to the other (Figs. 25.4, 25.5).

Figs. 25.4, 25.5 - Finished design proposal (Forsström R., Mac-Iver González C., Räty M., Varis M.)

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They also designed several different furniture for the space, like different working units and a large table for the material library (Figs. 25.6, 25.7). Most teams designed different kinds of furniture to bring more privacy for small team work (Fig. 25.8). Some teams designed smaller movable furniture for individual work, or working for two people (Fig. 25.9). One team even included a closed space where a student could relax or even watch a movie (Fig. 25.10). By far the biggest emphasis by each time was paid to the overall atmosphere and quality of the space as an area for working and learning. Some teams even added green plants and trees in to the space (Figs. 25.11, 25.12).

And of course in smaller scale big amount of attention was paid to the ergonomic solutions of the furniture and equipments.

Figs. 25.6, 25.7 - Finished design proposal (Forsström R., Mac-Iver González C., Räty M., Varis M.)

Fig. 25.8 - Finished design proposal (Holkko I., Hirvanen T., Reinikainen R., Matvejenko D.)

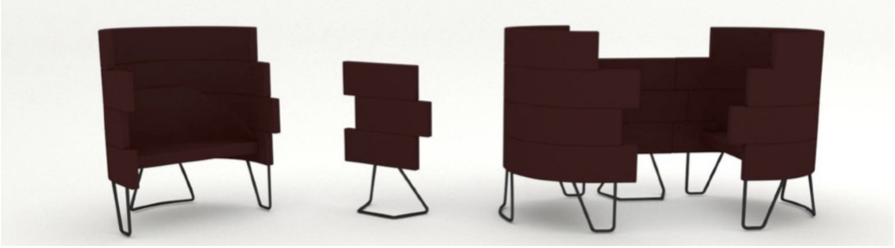

Fig. 25.9 - Finished design proposal (Hilden K., Madetoja A., Tammisto M.)

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Figs. 25.10, 25.11, 25.12 - Finished design proposal (Jelisejeff N., Kortelainen R.)

25.5 What Next?

Next the professors have the difficult job of deciding which designs to actually use and implement in the project space. As course works the results were exceptional, and all the professors and also the students were very satisfied with the results. The students also felt this was the most they have learned during their studies at Lahti Institute of Design. Unfortunately it seems that at the moment the university does not have the funding for such an extensive renovation for the space, but at least some changes will be made as early as the end of 2019.

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26. A User-Centred Approach to Visual Communication: the Design of Safety Traning Material for Migrant Farmworkers

by Lucia Vigoroso, Federica Caffaro, Margherita Micheletti Cremasco, Giorgia Bagagiolo, Eugenio Cavallo

Abstract

Visual communication allows to overcome language barriers in training. This issue is particularly relevant in agriculture where a high number of migrants with different languages, cultures and education are employed. This study aimed to design a new safety training material targeting migrant farmworkers in Italy by combining the principles of visual design with a User-Centred Design (UCD) approach.

Focus groups with migrant farmworkers and with trainers were carried out to identify the users' needs and preferences about safety training material. Subsequently, the drafted material was discussed to identify the best solutions in terms of comprehensibility and visual pleasantness. Finally, were assessed through a questionnaire the knowledge of safety topics prior to the training (T0) and after it (T1), and effort in learning and satisfaction for the material (T1), both in a control and in an intervention group.

The results showed that the intervention group reported higher safety knowledge at T1 compared to the control group. The study pointed out the effectiveness of the UCD approach when designing training materials for migrant farmworkers.

Keywords: Agriculture, User-Centred Design, Migrant farmworkers, Safety training, Visual communication.

26.1 Introduction

Since the '80s it has been observed that visual communication is a fruitful tool that allows the transmission of ideas and information more easily than written communication. Modern visual communication generally includes many forms of representation (e.g. typography, graphic illustration, graphs, maps, animation) to inform and educate the target users (Smith *et al.*, 2004). Whatever the form of representation chosen to convey a specific message, to develop a good and effective visual communication, the designers should take into consideration a set of principles and guidelines regarding graphic design (i.e. unity, direction, contrast, balance, simplicity, proportion and harmony), principles of the Gestalt theory (i.e. closure, common region, continuation, figure/ground, proximity, symmetry) and studies related to shape and colour perception, arranging the graphic elements within the space available to create a balanced composition (Smith *et al.*, 2004). This allows to make visual interfaces easier to read reducing the user eyes' visual scanning and the cognitive overload of visual channels (Mayer and Moreno, 2003).

26.2 Background

Considering that visual communication can better transmit risk related information compared to written text, easily illustrating which safe behaviors to adopt in dangerous situations and motivating the audience to action (Lundgren and McMaking, 2013), visual tools could be used as a valid support also in safety training in the workplace. Visuals are particularly helpful when training migrant workers, since they can help to overcome language barriers (Demirkesen and Arditi, 2015). In this field, the effectiveness of visual communication has been mainly investigated in the construction industry (Evia and Patriarca, 2012), and forestry (David and Asamoah, 2011). Less attention has been paid to visual communication for safety training in the agricultural industry, despite the high hazardousness of this sector (ILO, 2014). Agriculture is a particularly relevant sector in which to investigate issues related to visual communication, also because of the high rate of migrant workforce (150 million migrant workers worldwide, ILO, 2014), which often faces cultural and language barriers during safety training.

Little evidence is available in the literature about the effectiveness of visual training in the agricultural sector. The few studies available were conducted mostly among U.S. local workers and they showed that the dissemination of visual materials such as videos and posters, enhanced safety behaviors related to tractor rollover accidents (Brandt *et al.*, 2001). In another study, providing farmers and landscape workers with brochures on the importance of using Personal Protective Equipment (PPE) (Smith *et al.*, 2008), was associated with positive attitudes toward hearing protection.

Even less attention has been payed to the peculiar migrant workforce, despite the high rate of accidents and injuries in which migrant farmworkers are involved every year (Caffaro *et al*., 2018). The few studies addressing this population usually involved Mexican and Hispanic farmworkers in U.S. (Svensson *et al*., 2013), even though the migrant workforce is increasing in Europe, and especially in Euro-Mediterranean countries (Nori, 2017). The abovementioned studies highlighted the need to modify the training materials based on migrants' needs and to involve these workers in both the development and the evaluation of the training materials and programs (Menger *et al.*, 2016). Following these considerations, the aim of the present study was to develop a safety training material based on visual communication for migrants adopting the User-Centred Design approach (UCD) (ISO 9241-210, 2010). The study involved migrant farmworkers employed in Italian agriculture, in particular in the Piedmont region, north-west of Italy, which is characterized by higher percentages of both family and external migrant workforce (INAIL, 2012).

26.3 Methods

The study was carried out in the framework of the general and specific provisions of the Italian Legislative Decree No. 81 on 9th April 2008 on the protection of health and safety in the workplace. The decree introduces minimum safety requirements and a health and safety management structure, with specific figures in charge of the protection of workers' health and safety. The decree also institutes compulsory training for workers which is usually provided through lectures in which many slides are projected in front of a class of migrant workers.

The training material was developed following the User-Centred Design (UCD) ergonomic and iterative approach. In the UCD users' needs play a key role in defining the requirements of the system to be developed, and users themselves are actively involved throughout the design process with the aim to create a usable system (ISO 9241-210, 2010). Fig. 26.1 shows the different phases of the research.

26.3.1 Prototype Design 1

During the first phase of the study, the characteristics of the members of the on-farm health and safety management structure were defined based on (a) the analysis of the state of the art about the more effective methods to convey safety information, and (b) the analysis of the users' needs and requirements.

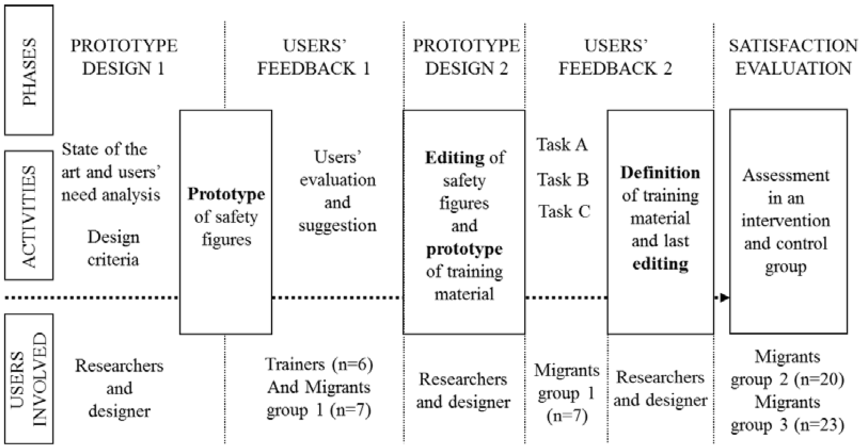

Fig. 26.1 - The phases of the research

a. Literature showed that static and animated pictures characterized by few elements, appeared to easily allow the comparison and re-inspection of the details of the actions depicted (Tversky, Morrison and Betrancourt, 2002); funny facial expression, movements and bright colors can attract users' attention (Evia and Patriarca, 2012); positive and neutral stereotypes linked to agricultural context (young male, always busy, straw hat, denim and tractor) may be used to depict the targeted figures, to help their identification (Kusis, Miltovica and Feldmane, 2014).
b. Four focus groups with trained migrant farmworkers (n=21 both EU and extra-EU origin), and one with trainers (n=6) pointed out the most and least comprehended topics by migrant workers during training courses and the formats and media preferred to provide the safety information. Six critical topics were identified: (1) members of health and safety management structure, and their tasks and relationships with the workers, (2) employer and employees' obligations and rights, (3) fire risk, (4) electrical risk, (5) PPE and when to use it, and (6) farm machinery related risks. Drawings and cartoons emerged as the preferred information source among the participants.

26.3.2 Users' Feedback 1

Based on the information obtained in the previous phase, the members of the on-farm health and safety management structure were drafted and were

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discussed with trainers (n=6), and with a group of migrant farmworkers (n=7, extra-EU origin). A questionnaire was orally administered to both groups to evaluate the comprehension and the easiness of identification of the depicted figures (Fig. 26.2). Then, the safety figures based on the participants' sugge-stions were edited.

Fig. 26.2 - On-farm health and safety management figures (1st prototype)

26.3.3 Prototype Design 2

The training material was developed in the form of a slideshow in 2D graphi-cs. The layout of the new training material was defined taking into account graphical concepts and visual factors (Goldsmith, 1987):

a **Composition:** the grid structure for the rearrangement of graphic ele-ments was used and the hierarchical relationship among the images was emphasized (Lee *et al.*, 2014);

b. **Colour:** it was used considering the context (i.e. agriculture) and its as-sociative and emotional value (Kandinsky, 1912) (e.g. red for fire);

c. **Emphasis:** the figure/background contrast was carried to extremes, ad-ding coloured details to a drawing grayscale background or vice versa;

d. **Font:** the "serif" font was chosen, considering both its legibility (related to the distance between each letter) and readability (the structure of the text as a whole) (Bernard and Mills, 2000). Boldface was used to em-phasize and to highlight specific keywords in the text.

e. **Synthesis:** the quantity of the text of each slide was kept to a minimum (Goldsmith, 1987).

26.3.4 Users' Feedback 2

As for the safety figures, different prototypes of the slides representing obligations and rights, PPE, and electrical, fire and machinery-related risks were designed and discussed with users, to determine their preferences. The preferred style of representation was discussed with the same migrant farmworkers of the users' feedback 1 phase, by means of three different tasks (A, B, C, Fig. 26.3) and then applied to all the other developed slides.

- **Task (A**) (Fig. 26.3a) aimed at identifying the most immediate way to represent the content of a speech balloon, choosing between signal words, numbers, pictograms, and letters – as in Schünemann *et al.* (2003).

- **Task (B)** (Fig. 26.3b) intended to explore the preferred representation to identify targeted PPE and context of use, choosing between simple drawings with coloured details or coloured photographs.

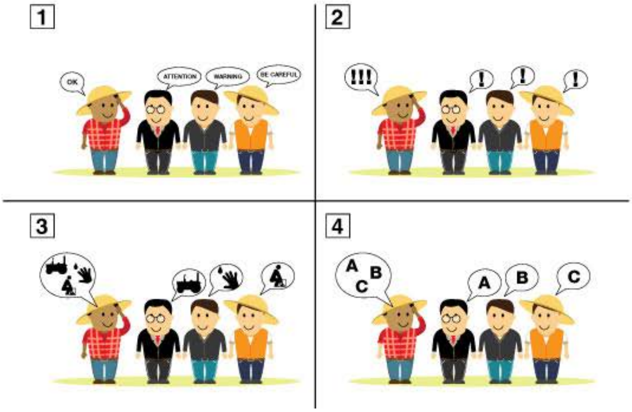
- **Task (C)** (Fig. 26.3c) aimed at exploring which type of emphasis of the figure/background contrast (coloured photographic details on a drawn grayscale background vs grayscale drawn details on a coloured photographic background) helped to identify on-farm safety risks.

As regards the written text, some short statements were used to highlight the key information on the slides. Based on the comments reported by some migrant participants, the Italian language was adopted, due to their desire to become more familiar with local language.

26.3.5 Evaluation

The edited visual material was then presented to a class of migrant (i.e. the intervention group, n=23, both EU and extra-EU origin) farmworkers during a safety training lesson (approximately 1h lasting) (Fig. 26.4). An ad-hoc questionnaire assessed the knowledge of safety topics presented during the training before (T0, naive knowledge) and after (T1) the training, effort in learning (T1) and satisfaction (T1). The same evaluation was performed in a class of migrants trained with the traditional material (2D slides, mostly written) (i.e. the control group, n=23, both EU and extra-EU origin) farmworkers during a safety training In=20, both EU and extra-EU origin) and then the data compared.

a) Task (A) The participants had to choose among 4 possible graphical alternatives for the content of a speech balloon describing an employee's obligation (namely, Art. 20 of the Italian Legislative Decree 81/2008, "the worker has to observe the instructions given by the employer, the executive manager and the supervisor, for the purposes of collective and individual protection").



b) Task (B) The participants were asked to choose between two visual prototypes the more effective in explaining which PPE was required and in which work situations.

c) Task (C) The participants had to choose between two prototypes the more effective in making the farm-related risks outstanding.

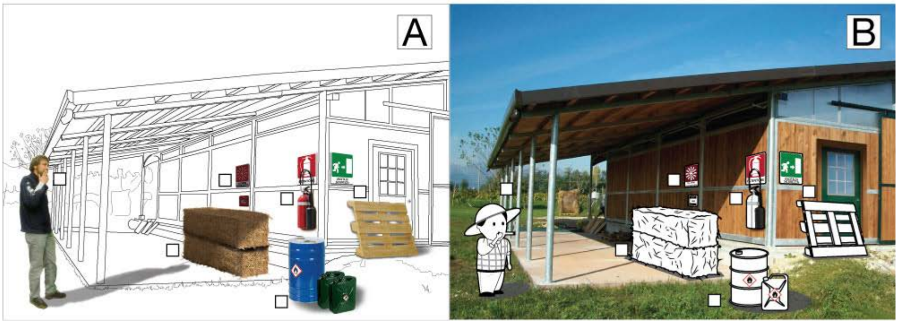


Fig. 26.3 - The three tasks submitted to users' evaluation

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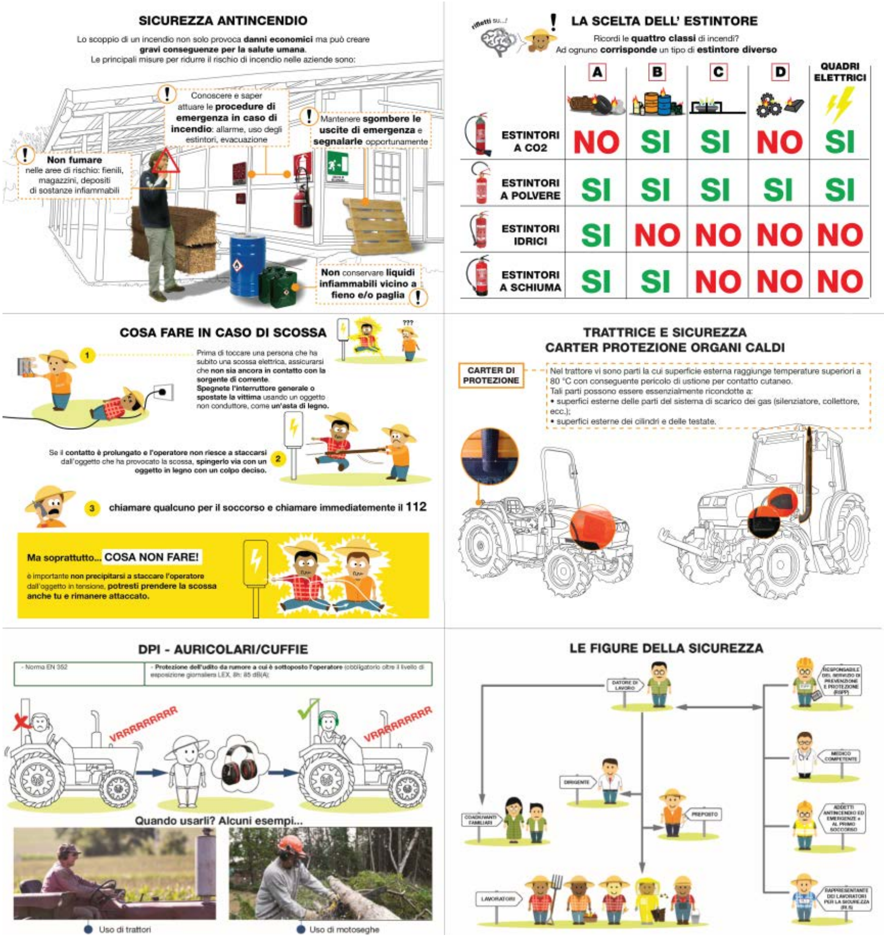

Fig. 26.4 - Some of the slides shown to the intervention group during the final training session

26.4 Results

26.4.1 Users' Feedback 1

The prototypes of the members of the on-farm health and safety management structure were printed on paper, standard size A4, and given to the participants for subsequent evaluation.

Regarding the identification of the safety figures, the farmworker and the doctor were the most recognized figures, while the less identifiable were the employer, the executive manager and the supervisor. Suggestions for their improvement from trainers and migrant farmworkers are reported in Tab. 26.1.

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Tab. 26.1 - Trainers and migrant farmworkers' main comments

Safety figures	Trainers	Migrant farmworkers
Employer	The look of the agricultural employer is more similar to the agricultural worker without a jacket or tie. With this clothes, he looks like a businessman	Our employer does not wear jacket and tie. His clothes are usually similar to ours I was incertain about the employer representation because some figures are quite similar I would add glasses to give him more importance
Farmworker	You could design more than one worker, maybe we can use a figure with a basket of fruit, or one with a bee-mask It may be useful to vary and not just keep only one ethnic group. Could be useful to represent workers with different skin colours	You can depict other additional object, like a pitchfork I work with animals, and I do not always use the pitchfork, maybe you can draw other hand tools near the figure of the worker to diversify his tasks in the workplace I can better identify myself and my friends in this representation if I see this farm worker with different skin colours, not only with white skin
Prevention and Protection Service Manager (PPSM)	In our working reality the figure of the PPSM and the employer could be the same. I think it would be better to represent the two figures in a similar way	The cross on the jacket is useful to recognize this figure but no specific changes were reported
Fire safety officer	You can add the helmet and the evaluation checklist folder for the PPSM and a yellow jacket with the cross for the fire safety officer	
Executive manager **Surpervisor**	The executive manager exists in the representation of the safety management structure but in fact it does not exist in the agricultural sector. However, we can use a more elegant representation	I preferred the executive manager when wearing a light shirt and a tie, while I prefer the supervisor without glasses and with a hat (similar to the worker's figure)
Doctor	A stethoscope can be used as an additional tool	No specific changes were suggested
Workers' Safety Representative (WSR)	No specific changes were suggested	No specific changes were suggested

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In addition, the trainers suggested to add the representation of family workers "because they could have important responsibilities in farm management, even if it is not much highlighted in our training program". The edited version of the on-farm health and safety management fugure is shown in Fig. 26.5.

Fig. 26.5 - On-farm health and safety figures after the users' feedback

26.4.2 Users' Feedback 2

The main results obtained from tasks A, B, and C can be summarized as follows:

- for **Task (A)** (Fig. 26.3a), the letters were indicated as the preferred graphic element (n=5), since, as two participants stated: "Seeing the letters is much easier to understand";
- for **Task (B)** (Fig. 26.3b), the majority of participants (4 out of 7) preferred the prototype based on photographs: "I better see which tasks the workers are performing". However, with regard to the representation of the PPE to be used, a preference for drawings emerged: "I choose the drawing representation because it is less loaded with images and it is easier to remember", "even if photography is more realistic than comics drawings, cartoons are more evident";

- for **Task (C)** (Fig. 26.3c), most of the workers (6 out of 7) preferred the representation with coloured visual elements in foreground: "[I prefer this] because the details have different colours, creating more contrast between figures and background, making them more comprehensible than photography".

26.4.3 Evaluation

The results showed significant differences between the two groups for all the variables considered. In particular, the intervention group reported significantly higher safety knowledge at T1 compared to the control group ($F(1,41)=4.10$, $p=.049$), significantly less effort in learning ($U=152.50$, $z=-2.17$, $p=.03$) and higher satisfaction ($U=151.00$, $z=-2.08$, $p=.04$).

26.5 Conclusion

When facing cultural and language differences among trainees, particular attention should be given to a User-Centred Design of the visual communication, to guarantee a more effective communication (Evia and Patriarca, 2012). The results of the present study are promising since the visual material developed thanks to the direct involvement of participants (trainers and migrant farmworkers) was particularly appreciated and reported positive feedback.

Based on the present results, some recommendations could be provided for future investigations addressed at improving the design of safety training material:

- Characters should be designed with features in which the users can identify and recognize themselves, not relying only on stereotypical representations. Characters should be contextualized;
- If used, the text should act as a support for the "key-images" to avoid language barriers as much as possible;
- The balance between solid and void, colour and grayscale, foreground and background, should drive users' attention on the more important details;
- The choice of using cartoons or photographs should be made considering the specific work environment, the target task and the tools needed to perform the task, to highlight the critical aspects while avoiding cognitive overload.

The study points out the advantages of the user-centred approach when designing training materials for migrant farmworkers, suggesting the necessity to further investigate its adoption also in other highly hazardous productive sectors, where migrants are employed.

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27. Inclusion of Interdisciplinary Three-Dimensional (3D) Printing Education to Occupational Therapy Curriculum

by Meral Huri, Gonca Bumin, Sinem Kars, Hülya Kayıhan

Abstract

Many occupational therapy (OT) programs have offered their students an education to increase activity participation. There is a limited number of studies on three-dimensional (3D) printing education integrated programs in OT curriculums. The goal of the study was to educate OT students about 3D printing in health care with practical lectures while increasing collaboration between designers, industrial engineers, architects and OT students.

OT students having Preventive Occupational Therapy and Environment course participated. As a part of the course interdisciplinary 3D printing education was given and students' tasks were evaluating disabled students with Canadian Occupational Performance Measure (COPM) to identify their needs and design a 3D-printed assistive device. Level of activity participation and satisfaction were evaluated before and after the use of the device. The results were analyzed by SPSS 19.

35 OT students designed 3D adaptive devices zipper holders, short and long finger device, pencil grips, chopstick holders, walking stick end cups, table planners, tablet and phone holders. By the use of 3D printed devices level of activity participation and satisfaction of disabled students were increased ($p<0.05$).

The trial 3D printing lecture in Preventive Occupational Therapy and Environmental Arrangements course is being reviewed to adapt it to OT curriculum. Schools of designing, architecture and engineering should include interdisciplinary 3D printing education to their curriculums to design and use this innovative opportunity for children with disability.

Keywords: *Three dimensional printing, Occupational therapy, Interdisciplinary education, Accessibility.*

27.1 Introduction

Three-dimensional (3D) printing use in rehabilitation is presented as a new and unique technology which improves the rehabilitation process and increases accessibility in a rapid way. 3D printing is a new creative and innovative opportunity in a variety of industries such as health care and rehabilitation to provide faster prototyping ideas, inventive problem solving and increased cost efficiency. Many rehabilitation and health sciences schools have adopted their education programs to educate their students to use 3D printing technology during their under graduate education to increase their student's creativity and problem-solving skills.

Acquaintance of the students with 3D technology and provide them specific directions, training and guidance to use this new technology as earlier as possible provide students to increase their view of innovation with understanding of increased accessibility and activity participation.

There are several studies highlight the use of 3D printing in rehabilitation process and encourage the involvement of it to the curriculum of the health care and health sciences programs. Many of the examples on clinical use of 3D printing in rehabilitation focused on creating prosthetics and adaptive devices. According to study of e-NABLE volunteers including teachers, medical professionals and students from various schools designed highly customized and cost-effective upper-limb assistive devices for children. Day and Riley presented that they produced a 56% cost-effective 3D printed adaptive device than the traditional device for their patient.

Occupational therapists, help their patients to increase their participation to life by increasing their independency in daily living activities by changing or adapting their skills and environment. It is vital to understand how the 3D prints will impact daily living along with body functions and body structure. 3D printing technology can provide clients with assistive devices that will increase their independence by decreasing the gap between the environment and the functional skills of the client. Therefore; an occupational therapist should fully understand the 3D printing process, begin and use 3D printing to design for his/her clients. Studies highlight that best 3D designs in health care are the results of studies in which multiple perspectives are used by professionals from different disciplines including medical doctors, occupational therapist, physical therapists, engineers, architects, and designers.

Although many health sciences and rehabilitation school's education programs have offered their students an education to increase activity participation in different environments; there is a lack of information on course-integrated programs for three-dimensional (3D) printing in occupational therapy education curriculum. Therefore, Department of Occupational Therapy at Hacettepe University Faculty of Health Sciences began exploring 3D printing for inclusion in the occupational therapy curriculum. The goal of this study was to educate occupational therapy students about use of 3D printing in health care and provide them practical experience, while increasing collaboration between designers, industrial engineers, architects and occupational therapy students.

27.2 Methods

The study designed according to Declaration of Helsinki; ethical permissions were taken from the university Ethical Committee and Education Commission of Health Sciences Faculty. Third grade occupational therapy students having Preventive Occupational Therapy and Environmental Arrangements course from Hacettepe University participated to the study.

First a detailed 3D printing education was given to occupational therapy students by an interdisciplinary group of advisor including an occupational therapist, an industrial designer and an architecture. Students' tasks included evaluating the disabled students with Canadian Occupational Performance Measure (COPM) to identify their needs and designing a 3D-printed assistive device to increase activity participation and accessibility in school environment as a part of their course. Level of activity participation and satisfaction of a school activity were evaluated before and after the use of 3D printed device.

27.2.1 3D Printing Education

During the planning phase, the authors contacted with Dr. Emre Huri, author of Hacettepe University Medtrain 3D ModSim (Medical Training and 3D Modeling and Simulation Project which is a European Union Erasmus+ Project to review on 3D printing in health care to get information about 3D printers which can print assistive devices for rehabilitation therapists, information about the types of objects wanted to be printed, the feasible printers and supplies, and information about how to educate occupational therapy students on designing. Later; brainstorming meetings between the lecturer and research assistants responsible for Preventive Occupational Therapy and Environmental Arrangements course, director and representatives of teachers of an inclusive school and Medtrain 3D ModSim Project Group including medical doctor, designers, industrial engineers, architects. A plan was developed that laid out the timeline, student project parameters, and roles of the involved partners. As the budget of the Project had a low budget to cover stationery supplies Medtrain 3D ModSim Project printer and a 3D scanner from Medtrain 3D ModSim group overtook the printing works of the students additionally to help to prepare the new curriculum of the lecture.

From our review of the literature and conversations with other academics who were involved in 3D printing, choosing the feasible printing program and the 3D printer according to our needs would be one of the biggest problems. By the help of Medtrain 3D ModSim group several printings were made and the best printed ones were selected to select the best program and the best technical support due to our needs. The lecturer and the research assistants of the course would not have the skills to design the 3D stereolithography files in detail so Medtrain 3D ModSim group helped to educate the faculty of the OT department for 3 full-day education. 3D MODSIM group made this education for free to increase their awareness and create an interest on 3D printing technology in health sciences for medical and adaptive devices. So occupational therapists served as a mediator between the client and designers, industrial engineers, architects and occupational therapy students. Together with Medtrain 3D ModSim group and OT faculty incorporated an assignment into an existing 16 week Preventive Occupational Therapy and Environment Arrangements course for a one-semester.

During this assignment students were required to identify a student from an inclusive school and create a prototype for a assistive device that would facilitate the student's ability to complete activities of daily living in school easier.

27.2.2 Evaluation Tool

Canadian Occupational Performance Measure (COPM) is an individualized outcome measure used to detect changes in the self-perception of the client's performance and satisfaction by identifying problems in performing activities of daily living. COMP can be used in any age population and diagnoses. Completed through a five-step semi-structured interview individualized to each patient. The five most important problems in performing activities of daily living according to the individual patient will be determined through a 10-point scale that will provide a guideline for rehabilitation. It's Turkish adaptation, reliability and validity study which presents high scores in Turkish language was done by Torpil *et al.*. For the reliability measure; intraclass correlation coefficients for the mean scores for performance is 0.67 (95% confidence interval) and Spearman's rho correlation coefficient for test-retest reliability performance is 0.89 ($p < 0.001$). For the satisfaction score intraclass correlation coefficients is 0.69

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(95% CI) and Spearman's rho correlation coefficient for test-retest reliability for satisfaction is 0.88 ($p < 0.001$).

27.3 Results

The results were analyzed by SPSS 19. Measurable variables were expressed as mean ± standard deviation (X ± SD), and percent (%) was calculated for the countable variables. To investigate the effectiveness of the use of 3D printed assistive device, the results obtained from the pre and post additive device use were compared with the Wilcoxon Paired Two Samples Test. In all statistics, p significance value was given as 0.05.

27.3.1 Results of Prototypes and 3D Printed Assistive Devices

Descriptive analysis was done for the prototypes and 3D printed assistive devices. Thirty-five third grade occupational therapy students grouped for five students in 7 groups and designed approximately 18 preliminary assistive device prototypes for the disabled children in the inclusive school. Prototypes of the assistive devices such as self-help materials and simple school devices (zipper holders, short and long finger device, pencil grips, chopstick holders, walking stick end cups, table planners, tablet and phone holders etc.) were created.

Fig. 27.1 - Examples of prototypes of assistive devices designed for the disabled students

5 of 18 preliminary prototypes were printed successfully, 2 needed to be printed in a different size and 1 needed adjustment which were done by the team of 3D MODSIM team (Fig. 27.1). Lecturers of the Preventive Occupational Therapy and Environmental lecture found the 8 prototypes useful.

27.3.2 Results of COPM

The use of 3D printed assistive device during participation to daily living activities increased the performance and the satisfaction scores of the disabled students. Fig. 27.2 presents the COPM scores before and after the use of 3D printed assistive device.

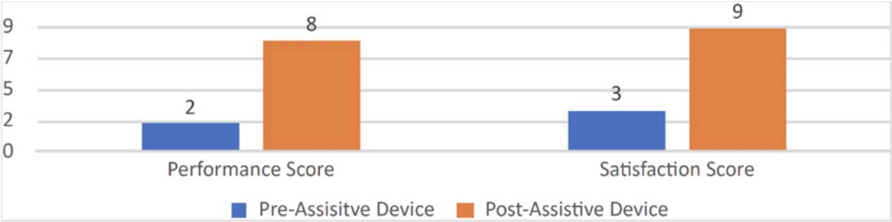

Fig. 27.2 - Performance and Satisfaction scores of COPM ($p<0.05$)

27.4 Conclusion

3D printed devices produced by occupational therapy students increased level of activity performance and activity satisfaction of disabled students in school activities. Consistent with the literature overall, the authors believe that they had produced a good result with adding a 3D printing education to the curriculum of an occupational therapy lecture. They also believe that meeting occupational therapy students with 3D printing in health care and educating them and the faculty has been a very interesting experience. Occupational therapy students learned that 3D printing is a new and cheap way to produce highly client centered, cost-effective assistive devices to improve activity participation in daily living activities. Consistent with the literature our students also gain a new and wide job skill with an experimental and creative learning opportunity to improve their problem-solving capacities which will help them to be much more successful in their professional lives.

Along with the occupational therapy students benefiting from the introduction education to 3D printing technology, disabled students and their families/care givers also gain an awarness on the topic. The experience has given OT students to introduce with new technologies, which we think increased their creativity and opportunities for future interdisciplinary team work. OT students, staff and also the families and care givers of disabled children also had earned a deeper understanding of a new way of increasing activity participation and satisfaction.

A wide knowledge about the operation of the 3D printers and use of software programs and scanning are now included in the occupational therapy curriculum. This collaborative project improved the visibility of occupational therapy in the university and also in the society.

The connections will between the different departments and professionals continue to improve new project frameworks and ideas for future collaboration. The occupational therapy faculty reached to discuss a new 16-week course of 3D printing for rehabilitation therapists including occupational therapists, physical therapists and speech and language therapists. Schools of designing, architecture and engineering should include interdisciplinary 3D printing education to their curriculums to design and use this innovative opportunity for children with disability. It is thought that interdisciplinary relationships formed by this project will facilitate future partnerships and projects.

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28. Future Step of Basic Design: Between Synaesthesia Didactic and Virtual Learning

by Yuan Liu

Abstract

One of the crises that design education faced today, is the unsettled theoretical model for the basis of design education, and an appropriate epistemology for design practice (Findeli, 2001). Basic design, as the foundation of any design process, has been reformed during decades after given birth by BAUHAUS, continuously provide new systematical theories to meet the needs of society and economic. The rise of technology and wide application of virtual teaching inject new vitality into design education, yet an in-depth analyzed approach of how and what could virtual learning been played within this concept are still to be defined.

This research starting from the investigation of existing innovative teaching cases with virtual learning, by analyzing the roles and teaching methods been used within didactic activities. The range of tools contains AR/VR/MR/VLE and interactive videos, the cases are analyzed under the 5 different areas which formed innovative teaching. The final finding would be a state of art that new technics played in didactic activities, also a discussion for how to use virtual reality in basic design.

Keywords: *Basic Design, Synesthetic Design, Innovative Teaching.*

28.1 Introduction

The discipline of basic design was born in Bauhaus, which dressed the fundamental principles of design to develop visual intelligence (Findeli, 2001). Meanwhile, virtual technics has shown its' value in didactic activities, especially in the architecture and medication field (Chu *et al.*, 2017; Milovanovic *et al.*, 2017). There are also some trials to teach basic design with VR (Neves and Duarte, 2015; Neves, Duarte and Dias, 2016), yet still remained the unsolved problems such as isolation between students, and the limitation of flexibility.

This research takes a close look at the innovative teaching methods through different disciplines, by analysis the cases that impart sensory knowledge, to discuss the reliability of teaching basic design (especially the multisensory knowledge) with new technologies. We evaluate the status quo of sensory approach in basic design by literature review, followed a secondary research to study the good practices of teaching by virtual reality. The goal is to frame the prospect of new basic design facing today's educational needs, and the appropriate virtual tools to support learning activity.

28.1.1 New Basic Design and Sensory Approach

The reason why design education must change, as Findeli (2001) stated in his article that the whole environment of design is safe and stable, yet changes are still needed to fulfill the task of design education, research and practice.

Over the decades, basic design has been developed and improved by numerous researchers and schools, based on Gestalt psychology and Bauhaus theory.

The systematic and objectives of basic design education are addressed first by Itten as:

"*Ensuring a manipulation to make students free from their biases, preparing the infrastructure for area selection with means tools effectively and giving the theoretical information with regards to the area for an objective perception*" (1967).

The definition has slightly changed by the researchers, such as "*the best pedagogic tool for developing visual intelligence in the present century*" (Findeli, 2001), "*the effort of expressing the abilities and power of creativity in aesthetic level and transfer of thinking, emotions, and impressions of a person*" (Besgen, Kuloglu and Fathalizadehalemdari, 2015). Boucharenc (2006) thinks that Basic Design could promote creative and experimental methodology to develops the learning style and cognitive abilities of students.

With the invention of computers and the use of software, the way of design teaching has ushered in change. In Lupton (2015), two-dimensional visual guide under today's design needs are discuss, the evaluation of basic design also been put as "*transparency and layering have always been at play in the graphic arts. In today's context, what makes them new again is their omnipresent accessibility through software*". It is to fulfill the needs between industrial production and art design that Bauhaus start to develop, and it is after the creation of software such as photoshop and illustrator in 1990s that educators have to balance the technical skills and visual thinking (Lupton and Phillips, 2015).

Basic design takes a great responsibility to open a path in future's didactic, which is yet, not systematically developed. The value of multisensory also arouses attention during design activities (Kakehi, Minamizawa, Nakatani *et al.*, 2012), which provides us the possible joint point with virtual technics.

28.1.2 Innovative Teaching in Design Education

Innovative teaching, also been put as "innovative learning", "innovative didactic", "creative learning", is first proposed by university in Iceland, and has been identified by several researchers as a "*creative emphasis in teaching, studying and learning*" (Gunnarsdottir, 2001), and "*the process of leading to creative learning, by implementing new methods, tools and contents that can benefit learners and their creative potential*" (Zhu *et al.*, 2013). In either definition, innovative teaching leads to a new way of didactic, also a creative progress for students to participate actively in the learning progress.

A huge number of studies investigate the different components of innovative teaching, new teaching methods are developed such as flipped classroom (Bergmann and Sams, 2012), experimental learning (Kolb, 2001).

Among them, new technics had range applications in AR, VR, MR and VLE. For instance, the didactic of architecture used AR and VR widely considering the needs of studying real environment, related researches in this direction are large in number (Dvořák *et al.,* 2005; Pezeshki and Ivari, 2018; Rodrigues, Werner and Landau, 2016). The other mentioned specific equipment used in architecture are: HMD VR, CAP VR, HYVE 3D (Immersive), Tangible AR, HMD AR, SDAR and ASR (Milovanovic *et al.*, 2017). New technologies benefit the way teachers evaluate students work (Dvořák *et al.*, 2005), it allows the architecture model to be evaluated all sides and with all details, provides the chance for solving more problems and getting new feedbacks. The educator can produce the knowledge more comprehensively, cover different layers of information, also find more problems from the students' assessment, in order to provide better guidance for teaching activities.

Innovative teaching also benefits basic design by VR tools and immersive learning CAVE (Besgen, Kuloglu and Fathalizadehalemdari, 2015; Neves and Duarte, 2015; Neves, Duarte and Dias, 2016).

These studies discuss the same problems – How would we teach design in the future? What kind of knowledge should we prove to build the foundation of designers?

28.2 Method

Our focus, also the interest of this paper, is the approaches of innovative teaching using new technics. We conduct a secondary research through online databases, the case studies are selected following these methods:

1. desk research, from electronic databases including Google Scholar, Semantic Scholar, Scopus and Web of Science, during 2008-2018 (recent 10 years). Each of the web-search follows the same keyword searching principle, browsed results with the same source will be merged;
2. video/image materials from the reports through internet;
3. personal document from related technic founder.

While browsing through, we used the keywords "innovative teaching" and "new technics". The results are further selected based on the integrity of the course and the clear reveal of the curriculum designer's ideas, to bridge the connection between selected technics and specific teaching goals.

Finally, we selected 20 cases from 13 different areas: *Art and Design; Industrial; Architecture; Industrial design; Mathematics, Geometry; Geography; Leadership; Language; Communication; Management; Engineering; IT;*

As the method for analyzing, according to Cachia's (2010) study, the composition of teaching activity could verify into five different areas, which is "Curriculum", "Teacher's Skills Development", "Pedagogic Practice and Assessment", "Tools and Resources", "Political and Cultural Context". Understanding the meaning of these five main areas are important, as it will be the framework to investigate the comprise of practices.

Amoung the five areas, "curricula and assessment" are very clear to define, have high impact for both the practice and evaluation of teaching activities. The component of "Tools and resources" aims to discuss the technics been used, the "Teacher's skills and training" part could benefits the teaching process in producing guidance.

28.3 Discussion

All the 20 cases have mentioned the part of "Tools and Resources", AR, VR and E-Learning Platform are most commonly used, MOOC/ E-Learning Platform, 3D software and Web-based model also take effort into the study. 12 of them considered the "Pedagogic Practice and Assessment" part, pay attention to the form of the course, evaluate the results of innovative teaching by students' performance and assessment. Only 10 of them consider to change the

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Tab. 28.1 - Analysis of the Cases

No.	Researcher(s)	Major	Workshop/ Project Name	Workshop/ Project Characteristics		Type of Innovative Teaching					Tools been used
				Length	Student Size	Curriculum	Teacher's Skills Development	Pedagogic Practice and Accessment	Tools and Resources	Political and Cultural Context	
1.	Michael A Filimowicz; Veronika K Tzankova;	Art; Design;	Digital Photography	/	100+	X		X	X		MOOC
2.	Claudia Susie C. Rod rigues;	Architecture;	VisAr3D	/	/				X		AR; VR;
3.	David Fonseca; Nuria Martí; Ernesto Redon do; Isidro Navarro; Al bert Sánchez	Architecture;	Representation Systems II	/	57	X		X	X		AR;
4.	J.Dvoˇrák; V.Hamata; J.Skácilík; B.Beneš;	Art; Design;	VR center	/	/	X		X	X		VR;
5.	Hui-Chun Chu; Jun-Ming Chen; Gwo-Jen Hwang; Tsung-Wen C hen;	Architecture;	/	/	39			X	X		AR;
6.	Nora Argelia Aguilera González	Architecture; Industrial Design;	Instituto Tecnológico de Monterrey	1 year	100+				X		AR;
7.	Julie Milovanovic; Gu illaume Moreau; Dani el Siret; Francis Miguet	Architecture;	/	/	/				X		AR; VR;
8.	M. Lehtonen; T. Page; G.Thorsteinsson; M. H epburn;	Architecture;	InnoEd	3 years	/	X		X	X		ICT; VR;
9.	Hannes Kaufmann;	Mathematics; Geometry;	Construct 3D	/	/				X		AR;
10.	V. Ramasundaram; S. Grunwald; A. Mangeot; N.B. Comerford; C.M. B liss;	Geography;	envi- ronmental virtual field laboratory	/	/	X		X	X		3D software;
11.	Stephen Bronack; Ro bert Sanders; Amelia Cheney; Richard Ried l; John Tashner; Nita Matzen;	Leadership; Educational Studies;	ITC 5220; LIB 5020;	/	/	X		X	X		VR;
12.	Rita Calabrese; Kathe rine E. Russo;	Language;	SBATEYL	10 weeks	/		X	X	X		Web-based model;
13.	Leslie Jarmon ; Tomo ko Traphagan; Michae l Mayrath; Avani Trivedi;	Communication;	/	9 weeks	/	X	X	X	X		VR;
14.	Carmen Pastiu;	Collaborative Environment;	/	/	120				X		E-learning Platform
15.	Masataka Okutsu; Dani el DeLaurentis; Sean B rophy; Jason Lambert;	aerospace Engineering Design;	Aeroquest	40h	135	X		X	X		E-learning Platform
16.	Leah T. Ritz;	Instructional Design;	CAVE	/	/	X		X	X		VR;
17.	Michelle Honey; Kelley Connor;	Haemorrhage Management;	/	/	/				X		E-learning Platform
18.	Gabriele Piccoli; Rami Ahmad; Blake Ives;	IT Skills;	/	1 semester	146	X		X	X		Virtual Learning Environment;
19.	Tome Page; Gisli Thorstei nsson; Miika Lehtonen; Ha, Joong Gyu;	Design and Technology;	InnoEd;	3 years	/				X		VR;
20.	Arzu Özen Yavuz; Tayfun YÖldÖrÖm;	Architecture;	/	4 weeks	/				X		E-learning Platform

structure of the course, by adjusting course time, student groups and content of teaching to meet the needs of innovative teaching.

Two research group pay attention to the "Teacher's Skills Development", develop the teachers understanding and ability of using and teaching new technics, none of the research group mentioned "Political and Cultural Context", as the same statement by Cachia (2010), the context of the culture is very hard to define. The length of the projects are not commonly mentioned, the range of timing varies from 40h to 3 years project, which means that new technics could support both short workshop and longtime projects. The student size also includes small groups and large public course, the student group has not influenced by the technic limitations such as AR and VR.

28.4 Results

During the study, several discussions and insights are drawn from the research.

1. Very few cases have a comprehensive understanding of innovative teaching, they lack systematic research and guidance during designing educational courses and selecting innovative tools, and didn't present a specific reason for choosing the technic.
2. The form of course, the tools been selected, the assessment and evaluation have not been well integrated to achieve specific teaching goals and objectives, the connection between them is more supervised, lacking scientific linkage. The reason of choosing the typical technics is not well stated, and the evaluation of the results are also incomplete.
3. In general, some of the cases lack sufficient knowledge to frame the course design, including the form of student groups, the guidance through new technics training and the interaction between teachers and students.
4. Compared with the E-learning platform and Web-based model, the problem of isolation and lack of communication of teachers are more obvious in environments which only use VR and AR devices, for some course, self-directed learning can play a sufficient role, yet for the courses in design and architecture, a certain level of teacher-student guidance and communication is necessary.

In innovative education, a more systematic and accurate model is needed to provide advice and guidance for subsequent curriculum design through the definition of curriculum methods, course content, teacher responsibilities, and tool characteristics. The design of the innovative course should not be independent, intermittent, but to be three-dimensional, well considered.

28.5 Conclusion

As the focus of this paper is on design education, we propose several possibilities of teaching basic design with new technics. First of all, based on the specific needs of design learning, the teaching activity needs to contain all three kinds of interactions (learner-instructor; learner-learner; learner-content), the problem of isolation by virtual reality is need to be circumvented. The technic of a CAVE is ideally based on this stage of research, as it has an open place for interactions between leaners and instructors, also provide the teaching content in a really interactive way.

Secondly, the components of student groups and teaching times could be considered by formulating a new form of teaching activity. As usual, the design students spend a lot of time doing group works by both hands and computers, that means there is a balance work to do between virtual technics and handmade tools.

The involvement of new technologies provides a richer possibility for innovative teaching, with more varied venues and more interesting interactions. We do see the potential of using virtual reality into basic design education, as it could provide rich interactions within different levels of sensory, and can be combined with various teaching scenarios and instruments.

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29. Emotional Design and Neuroscience: Definition and Application of a Tool for Designers

by Alessio Paoletti, Loredana Di Lucchio, Fabio Babiloni

Abstract

The study evaluates whether it's possible to interpret the neurophysiological responses of the User Experience from the design perspective. Cognitive Neurosciences are providing an increasing body of knowledge about the user response, however this information is dense and not easily accessible or usable for designers. Therefore it is necessary to provide the designer with a tool to interpret the neurophysiological response. We conducted a study, both by reviewing the Emotional Design Research's literature and by participating to in-laboratory experiments together with neuroscientists.

The tool of methods CARDS have been defined, that makes neurophysiological data interpretation readily and accessible for designers. The article describes the CARDS's definition and their usage. By conducting interviews with professional designers and researchers, the group have largely agreed on the following possible uses of Cards: 1) interpreting the neurophysiological data elicited by a given design product; 2) designing a brand new design product with the goal to leverage on a specific neurophysiological index; 3) alter a design product, and by redesigning it, leveraging on emotional aspects not considered before in the original design.

This is the first beta version and the cards will be evaluated through a design-in-use study. Finally, CARDS could be also used as teaching tool in design courses, to raise awareness of future designers on both the cognitive and affective needs of the users, seen from a different perspective.

Keywords: *Emotional design, Neuroscience, Neurodesign, Method cards, User-Centered Design.*

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29.1 Introduction

This contribution is derived from the doctoral thesis of the first Author (Paoletti, 2019) discussed on March 5th, 2019, which focused on Design and Neuroscience.

The research investigated whether it was possible to interpret the neurophysiological responses of the User Experience from the design perspective. Most of the research was on the identification of the possible areas of connection between these fields, but part of the Research has been dedicated, in a still marginal way and which needs further development, to provide designers with some practical tools. Therefore, Methods CARDS have been defined as a tool, which makes neurophysiological data interpretation readily and accessible for designers without that specific background.

29.2 Background

User Centered Design (UCD) requires designers to be focused on users since early stages.

Designers interested in enhancing user emotional and cognitive response, can also nowadays make use of tools and methods of Cognitive Neurosciences. Designers are therefore required to have specific knowledge on how to interpret these specific data.

As widely accepted, emotion can be considered as the expression of three indicators, which constitute the triad of emotional response: motor expression, physiological excitement and subjective feelings (Smelser and Baltes, 2001). On the basis of which of the three indicators we observe, different instruments and methods are adopted, with specific advantages.

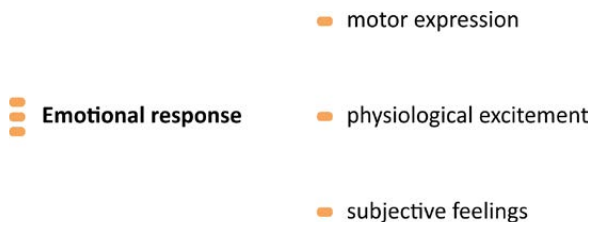

Fig. 29.1 - The triad of emotional response

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By observing the neurophysiological indicators, we can: overstep the semantic and cultural limitations that other tools pose (for example the verbal tools of self-report); record the user's response simultaneously with the product experience; collect information on the emotional states of which the user is not aware and which, therefore, wouldn't be able to describe in a self-report.

Cognitive Neurosciences are providing an increasing body of knowledge, however this information is dense and not easily accessible or usable for designers.

Therefore, it was necessary to provide the designer with a tool to interpret the neurophysiological response.

Among the most relevant neurophysiological indexes, scientific research has accepted the triad: MENTAL EFFORT, EMOTIONAL INDEX, INTEREST. With the triad of cognition, emotion, and behavior we can depict the quality of the user-product interaction in a holistic approach.

Fig. 29.2 - Neurophysiological indexes of user-product interaction

Specifically, the Mental Effort index is related to the Cognitive Effort. The latter can be measured by means of the EEG frequency band between 4 and 7 Hertz, called Theta waves. A user who wants to achieve a task by means of a product, needs to understand how to use it to get the desired goal. The more Mental Effort the user shows, the less the product is easy to be used. "*So it would make sense that simpler, easier-to-process designs might be favoured […]. Psychologists call this "processing fluency"*" (Bridger, 2017).

While the Mental Effort Index is related to the cognitive response, the Emotional Index and the Interest Index are related and describe the affective response. The emotional response, in fact, can be represented by means of few fundamental dimensions, among which the most commonly accepted are: valence, arousal, approach with drawal. The Valence/Arousal variations can depict the emotional states of the user towards a stimulus, and such variations are expressed with the Emotional Index (EI).

Differently from the ME index, the Emotional Index (EI) doesn't take into account brain processing, but it relates to peripheral parameters. The Cognitive Function that is relevant in the Emotional Index is the Decision Making, that before the somatic marker defined by Damasio in 1994 was totally unbalanced on the rational meaning (Babiloni *et al.*, in press). When the individual reacts to the external environment, optimizing time and results, the somatic marker brings past experiences in the process of the Decision Making. The somatic marker helps to understand how the cognitive and affective response work together rather than subsequentially. To measure the valence and the arousal, two neurophysiological variables have been used in scientific literature: the Galvanic Skin Response (GSR) and the Heart Rate (HR). The GSR traces changes in the arousal, the HR represents the valence (Russell and Barrett, 1999; Baumgartner, Esslen and Jäncke, 2006; Cacioppo *et al.*, 2000). Since the Emotional Index expresses the valence and the arousal, depicting the emotions the user feels during the interaction with the product, the better the Emotional Index, the better the user-product interaction.

Finally the Interest Index (INT), describes a reaction that, unlike the other two indices, does not depend directly on a specific cognitive function, but on the particularity of the stimulus in relation to the organism. The object of analysis is the behavior of the body in approaching with drawing by a specific stimulus, rather than a given cognitive function. Approach or withdrawal behavior depends on an appraisal process. Since the emotions have an instrumental role, they are responses to perceived changes and they have a situational meaning that is specific to the context. This process is a non-conscious sense-evaluation of the external stimuli, with short duration, but it does not evaluate the stimuli as such, it gives a personal significance of the event for the individual wellbeing. The Approach/Withdrawal can be measured by means of the frequency band comprised between 8 and 12 Hertz, named Alpha waves. From a designer perspective, the higher the Interest, the better the user-product interaction.

29.3 Methods

With the goal to identify possible areas of connection between Neuroscience and Design, we conducted a study both by reviewing the Emotional Design Research's literature and by participating to in-laboratory experiments together with neuroscientists. Particularly, we have been part of a multidisciplinary research group inside BrainSigns (BrainSigns Srl, 2018), a spin-off of Sapienza University of Rome that is conducting researches on recording and performing high quality analysis of brain and other bio signals, to apply the research's re-

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sults to different fields such as Neuromarketing, Human Factors and Clinical Applications. For confidentiality reasons related to BrainSigns' researches and its customers, we can't go into details describing their specific Protocol, but we can describe both the scientific researches from which they started and the tools they used. The scientific bases of the experimentations are the references related to the neurophysiological indexes (ME, EI and INT), that we have described in the previous paragraph. The Protocol adopted, designed by BrainSigns, allowed the research group to assign precisely the variations of the values to the exact moment of the user-product interaction. The stimuli selected for the experimentations have been packaging from the food and beverage industry. In particular, we used flexible packaging since it is going to be one of the most relevant innovation in the packaging industry in the next years (Bemis Company, 2015; Technavio, 2016; Transparency Market Research, 2018).

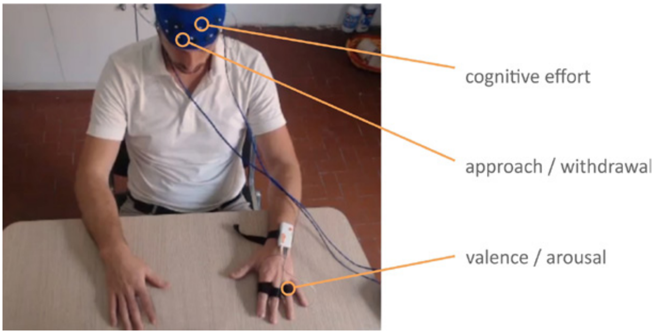

Fig. 29.3 - Measuring neurophysiological data

As shown in Fig. 29.3, neurophysiological data can be measured simultaneously with the exposure of the subject to the stimulus, rather than being detected a posteriori, avoiding the time-gap and its disadvantages that affect the measurements' quality (Scherer, 1986). Moreover, the portability of these tools allows us to detect the user's involvement with the stimulus in its original context, thus being able to return the image of a context of use adhering to the real one.

The tools used have been portable brain-scanning helmets and Galvanic Skin Response units, that leaved the users free in their movements and capabilities of manipulating the stimulus. The EEG have been performed placing a series of sensors over the user's scalp by means of an elastic tights; its adherence to the users' head has been improved with a water-based gel. The EEG tool have been developed in-house by BrainSigns. To measure the variation of the Galvanic Skin Response, instead, the tool used have been a Shimmer3

GSR+ (www.shimmersensing.com). It measures the skin conductivity between two electrodes, that are attached to two fingers. It monitors the sweat glands' activity and the increasing of the moisture on the skin, that allow the current to flow more readily. That changes the balance of positive and negative ions in the secreted fluid and therefore it increases the skin conductance.

These tools produce a cloud of data that must be subsequently filtered through specific software, in order to identify the most representative data. On the basis of these, the three neurophysiological indices will be defined. One of the peculiarities of the Protocol defined by BrainSigns is being able to establish exactly the moment in which the neurophysiological value was detected, thus being able to say exactly, using the words of the Design Research, to which type of interaction it refers to. In fact, as highlighted by Desmet and Hekkert (Desmet and Hekkert, 2007), the user-product interaction can be of three types: Instrumental Interaction, where the use is involved; Non-Instrumental interaction, where the users don't adopt the stimulus as a mean to get a desired goal; Non-Physical interaction, where the users don't have the stimulus physically but it's proposed in a different way.

The protocol defined by BrainSigns allows to analyze all the typologies assigning to each one the specific data. This, from a Design perspective, allows an interpretation in line with the evidences of the Design Research. In addition to this alignment between Design Research and Neuroscience, we found a potential overlap of the three neurophysiological indices with the three processing levels defined by Norman (Norman, 1988; 2004): cognitive, behavioral and visceral level. The scientific basis on which we have created this parallelism is extensively described in the thesis of the first author (Paoletti, 2019).

Therefore, by participating in a multidisciplinary research group composed of researchers in the fields of Neuroscience, Psychology, Biomedical Engineering and Communication Experts, we identified a certain integration of the research of Cognitive Neuroscience with the research of Emotional Design. Once the potential has been identified, we have defined a correspondence matrix. By combining the results in the field of Emotional Design, we depicted the Alpha Matrix, to interpret neurophysiological data from the Design perspective. The goal of the matrix is to interpret neurophysiological data from the perspective of design and, ultimately, transform them into design indications. It represents a possible bridge between Design and Neuroscience, by providing with a reasonable degree of approximation, guidelines to interpret neurophysiological data. As the latest research about Neurodesign found, what can be depicted are trends rather than precise results (Bridger, 2017).

From a purely theoretical analysis of the Design Research's literature, and from an observation in-the-lab of Neuroscience's tools and methods, we associated

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the interpretation of the Mental Effort to the Reflective level defined by Norman, and to the Instrumental Interaction defined by Desmet and Hekkert. We have instead associated data interpretation of the Emotional Index with the Visceral Level defined by Norman, and with the Non-Instrumental interaction defined by Desmet and Hekkert. Finally we associated data interpretation of the Interest index with the design level named Behavioral according to Norman's research, and with the Non-Physical interaction as defined by Desmet and Hekkert.

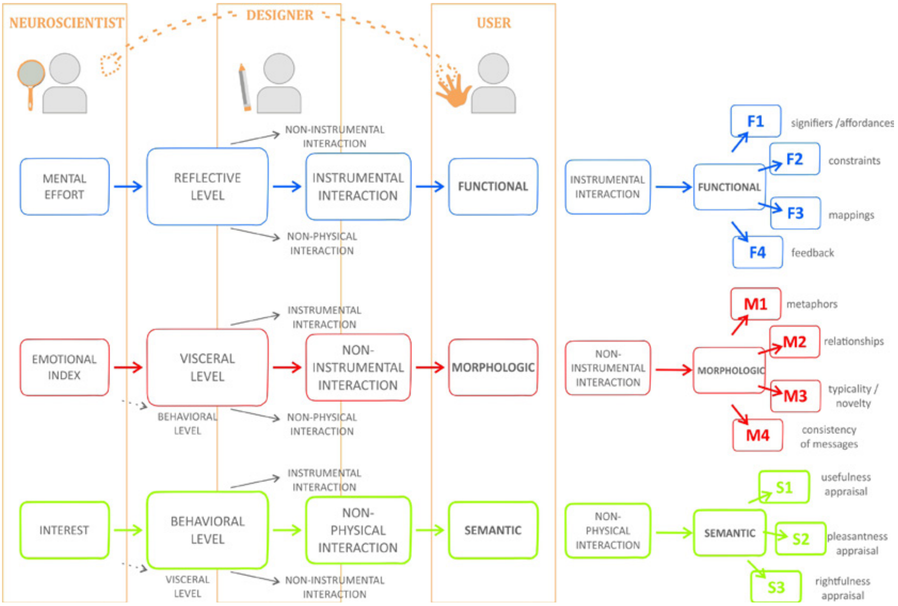

Fig. 29.4 - AlPha matrix, linking Neuroscience and Emotional Design

The designer who tests a product in a focus group, and wants to know its product-experience, can potentially use the tools adopted by cognitive Neurosciences and measure the experience by means of these three indices. To support data interpretation, we transferred the AlPha matrix content in a card-based design tool, that support designers in taking into account cognitive and emotional response, from the Cognitive Neurosciences' perspective.

29.4 Results

One of the Research's results is the definition of the Cards tool, that offers guidelines for the interpretation of the given neurophysiologic data, for those

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who have a background in design. The cards consist of three groups, one group for each of the 3 neurophysiological indexes. They are recognizable by their color code: blue identifies the Functional sphere linked to the Mental Effort, red the Morphological sphere linked to the Emotional Index, green the Semantic sphere linked to the Interest.

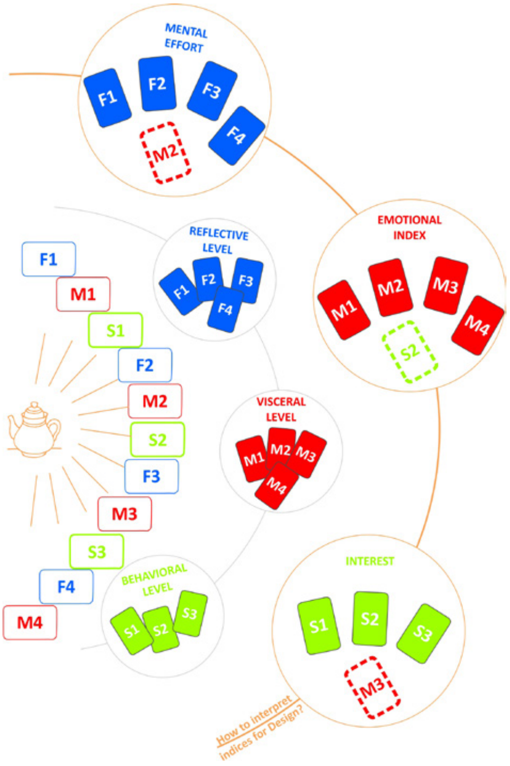

Fig. 29.5 - How to use the CARDS

The front part of the Card contains an identifying letter of the sphere to which it belongs, it is followed by a heading that explains the sphere of belonging and a sub-header that describes the principle according to which to interpret the data. On the back there is a short sentence in bold which explains the nature of the interpretative principle. This is followed by the questions that the designer can ask to interpret the data.

By conducting interviews with professional designers and researchers, the group largely agreed on the following possible uses of Cards: 1) interpreting the neurophysiological data elicited by a given design product; 2) designing a brand new design product with the goal to leverage on a specific neurophysiological index; 3) alter a design product, and by redesigning it, leveraging on emotional aspects not considered before in the original design.

Simulating the use of the Cards, for example the designers who sees the product eliciting particularly inconvenient values of EI, will have to use the RED CARDS and ask the questions proposed. The purpose of these questions is to guide the designers in reasoning that can lead them to identify aspects of the product that potentially elicited that specific neurophysiological data, in that specific phase. There is no hierarchy in sequence usage: designers can ask all the questions proposed in the cards starting from the one they prefer. The Cards are subdivided according to the principles to which they answer and therefore represent macro-groups of questions. The designers can then first identify which of the Cards is the most relevant and then go into the specific. The tools of Cognitive Neuroscience must be complemented with the already known tools, such as semi-structured interviews. Sometimes the Cards suggest to compare the measured data with the information gathered in a verbal manner.

Fig. 29.6 - CARDS's complete set

29.5 Conclusion

The User Experience is nowadays potentially analyzed by adopting also the Neuroscience's tools and methods. For designers is therefore necessary to have tools that can support the data interpretation, with the goal to transform the neurophysiological data in design insights. By conducting a study both by reviewing the Design literature and participating to in-laboratory trial with researchers in Neuroscience's field, we found that Neuroscience and Design can strongly collaborate, with the goal of even better understand the user and, ultimately, to define designs that even more meet the user's expectations. We therefore developed, and subsequentially tested, Methods CARDS that make neurophysiological data interpretation readily and accessible for designers, without a specific background in neuroscience. In conclusion, the Cards help to think about which aspect of the product may be susceptible of improvement, but the choice of where to operate and how to re-design the stimulus remains at the designer's experience. This is the first beta version and the cards will be evaluated through a design-in-use study. In the next developments, three professional designers will use the cards to interpret three different stimuli, in which we expect one of the three neurophysiological indexes will predominate. Finally, CARDS could be also used as teaching tool in design courses, to raise awareness of future designers on both the cognitive and affective needs of the users, seen from a different perspective. What the Neurosciences can represent is an expansion of the knowledge on which the designers operate their choices, but the design choice for its nature is a synthesis that belongs to the personality of the designer.

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30. Teaching Design Thinking Through Flipped Classroom

by Marita Canina, Carmen Bruno, Laura Anselmi

Abstract

Digital technology has improved our lives in different ways and domains, also in the education field. Innovative teaching methods should integrate the use of digital technologies to enhance student engagement, support any education environment and encourage both teachers and learners that are now relying on them for a different purpose from conducting research to collaborating with peers. The actions have to foster innovative didactics that give value to the learner's passions and skills, increase flexibility and trans-disciplinarity, and boost project-building didactics.

These changing are also occurring in the design process education.

This paper aims to present a creative learning experience, based on the "flipped classroom" methodology enriched by the integration of other learning engagement strategies, developed by IDEActivity Center to explore the Design Thinking (DT) process and tools. The teaching project promotes forms of innovative learning of the Design Thinking (DT) process integrating different engagement strategies for adult learners including, Think-Pair-Share, Role-play, Flipped-Active Learning, Problem-based learning.

The workshop designed for flipped DT learning is an experiential format applicable in any context, whether educational or corporate, in a public or private institution. The learning experience was experimented in a didactic module of Product Design on a Master's course at the Politecnico di Milano.

Keywords: *Design Thinking, Adult learning, Engagement strategies, Critical thinking, Problem based learning.*

30.1 Introduction

Over the past few years, the research has highlighted the potential value of student-centred learning environments (Kim *et al.*, 2014). When adult learners are active in their learning they are able to develop critical thinking skills, receive social support systems for the learning, and gain knowledge in an efficient way (Karge *et al.*, 2011).

The engagement is considered multidimensional, involving aspects of learners' emotion, behavior, and cognition (Fredricks, Blumenfeld and Paris, 2004). Designing a new learning experience means including all these dimensions. As designers, we embraced the ideas of researchers that considers engagement as a process, instead of conceptualize it as a result (Appleton, Christenson and Furlong, 2008; Skinner *et al.*, 2008).

The teaching project presented here, promotes forms of innovative learning of the Design Thinking (DT) process integrating different engagement strategies for adult learners including, Think-Pair-Share, Role-play, Flipped-Active Learning, Problem-based learning. The process for the construction of the DT module via flipped classroom started with the study of andragogy, a focus on the engagement strategies, and the exploration of the skills that young adults ought to acquire to meet the future challenges (European Commission, 2007).

30.2 Learning Engagement Strategies

Knowles, Holton and Swanson (2005), that extensively studied adult education, coined the term "andragogy" to signify methods and core principles used to build more effective learning processes for adults' learner. Knowles emphasizes that adults need to be involved in the preparation and evaluation of their instruction and expect to take responsibility for decision; these aspects combined with motivation creates a strong ecosystem to acquire knowledge.

Andragogy makes the following assumptions: adults need to know why they need to learn something; they learn best by participation in relevant experiences and practical information, so their approach to learning is problem-solving rather than content-oriented; they learn best when the learning subjects have immediate relevance to their job or personal life (Knowles, Holton and Swanson, 2005). Fig. 30.1 shows the core set of adult learning principles with the six principles of andragogy.

It follows that andragogy means that adults learning needs to focus more on the process and less on the content being taught. Strategies such as peer-learning, role-playing, problem-based experience, case studies, and self-evaluation are most useful. Instructors adopt a role of facilitator or resource rather than lecturer or grader. In order to define the specific goals and purposes of the teaching project, we carefully explore effective teaching strategies designed to enhance skills and gain content knowledge.

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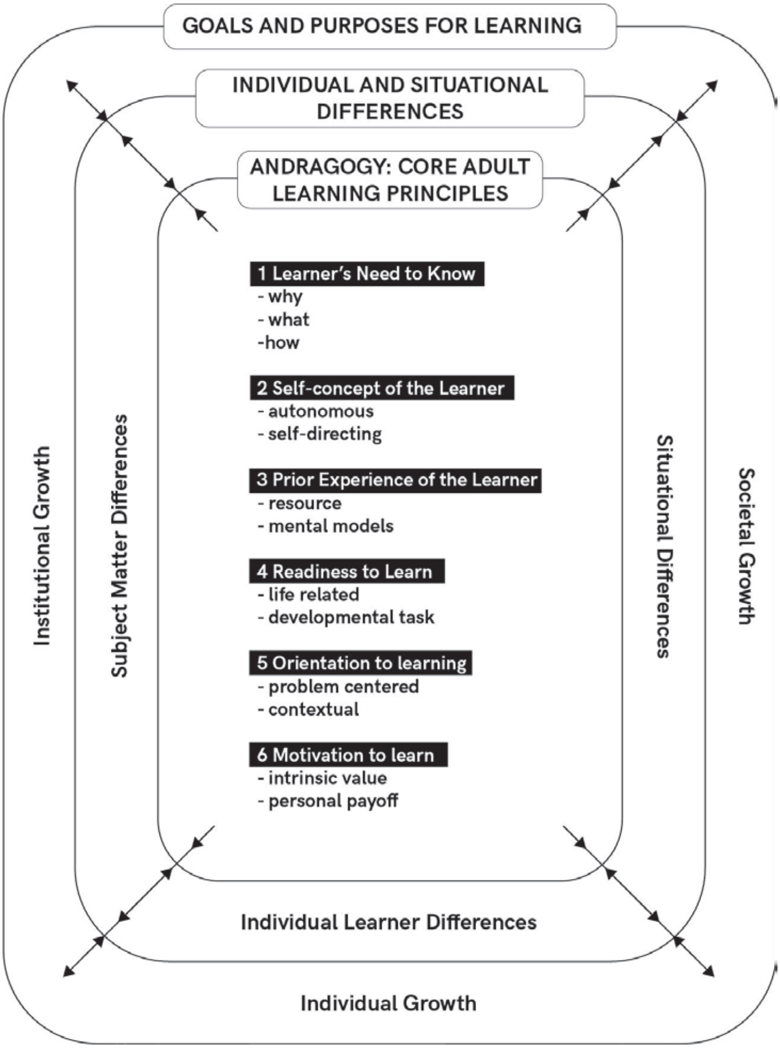

Fig. 30.1 - Andragogy in practice. Readapted from Knowles, Holton and Swanson (1998)

We highlight here those that we chose because they best fit with the DT learning experience: Think-Pair-Share, Flipped-Active Learning, Role-play, Problem-based learning (PBL).

The ***Think-Pair-Share*** is an active and cooperative learning strategy, developed by Lyman (1987), that invite students to think about a specific topic, pair with another learner to examine their own thinking, and then share their ideas with the group to develop the ability to consider and appreciate the different viewpoints of their peers. Think-pair-share is designed to help the student to understand the concept of the given topic, develop ability to filter the information and formulate an idea or thought, and draw conclusions.

We have taken into consideration the ***Read-Write-Pair-Share***, a variation proposed by Fisher, Brozo, Frey and Ivey (2007), in which in the first part the student reads information independently and then writes his/her considerations about it. The knowledge is enhanced by the conversation and expansion of the thoughts with the peers (Karge *et al.,* 2011).

Flipped learning is an active learning approach in which the traditional learning material that transmits information is given before class, so that class time is dedicated to deepen understanding through discussion with peers and problem-solving activities facilitated by teachers (Bishop and Verleger, 2013; Andrews *et al.*, 2011). Abeysekera and Dawson (2015) define the flipped classroom as a set of pedagogical approaches that: (1) move most information transmission teaching out of class, (2) use class time for learning activities that are active and social and (3) require students to complete pre- and/or post-class activities to fully benefit from in-class work. Bull (2013) added: "*using technology in a way that allows the teacher to spend more time addressing individual needs of learners and interacting with students instead of lecturing*".

According to Talbert (2014), for a flipped classroom experience to be effective, it should include: 1. highly structured pre-class assignments which are geared towards introducing the students to the new theoretical concepts; 2. means of accountability to ensure that students complete the required pre-class assignments and out-of-class work; 3. well-designed sense-making activities for the students to engage with during lecture time; 4. open-lines of communication throughout the course so that students can interact freely with the instructor. Those principles represent the theoretical frameworks that guided the design of the learning experience activities.

We then considered two learning strategies that are very close to the intrinsic nature of design: solving complex problems in real situations. In fact, the Role play and the PBL allow to activate simulation scenarios.

Role-play allows learners to explore realistic situations by interacting with other people and playing roles that enable spontaneous human interaction involving realistic behaviour. It provides the possibility of significant learning, allowing not only a self-learning about how to think and react in a particular situation and possible suggestive solutions for resolving the problem or analysing the situation, but also helps in understanding others perception about the situation or issue.

Problem-Based Learning (PBL) (Barrows and Tamblyn, 1980) activities usually focus on actively engage student in learning communities by solving complex, openended problems/scenarios (Karge *et al.*, 2011), collectively and creatively.

Problems are designed to introduce the material as well as provide learners with a deeper learning opportunity. The PBL process encourages participants to take on the responsibility for their learning by applying their research, and their collaboration and also providing input from their relevant past experience and knowledge (Savery, 2006).

We took into consideration these strategies for designing a framework for the flipped classroom DT module, described in the next sections.

30.3 Design Thinking Process

The objective of the didactic experience is teaching the DT process through the flipped classroom approach enriched by the integration of the learning engagement strategies described above. The experience has been constructed on DT process configured by IDEActivity Center (2014). It is a Human-Centred Design process merging Creativity and Design Thinking approach to involve people with different competencies to actively collaborate for the definition of a design challenge and the development of innovative ideas or strategies.

It focuses on two main stages, Explore and Generate, both divided into two phases: Clarify Goals and Define Opportunity the former, and Idea and Prototype the latter. Each process phase has specific objectives, performed through the integration and amalgamation of different known and ad hoc techniques and tools designed to stimulate creativity and generate suitable concepts in several creative sessions.

The four phases defined above represent the key points of the DT process to be transferred, learned and carried out through the didactic experience.

30.4 DT's Experiential Module in Flipped

According to the considered engagement strategies, the designed module is based on the development of a ***project-based activity, starting from a design brief*** (Canina and Bruno, 2018). This active engagement experience allows understanding the fundamental notions of DT, studying in-depth all the phases of the DT process and its tools in the pre-class work activity, and putting them into practice on a design challenge during in-class activity.

The activities designed for the module intend to let the learners to completely organize, prepare and run the collaborative session according to ***the pre-established roles.*** The module has been designed with role play mechanism in which the participants must take on a role throughout the course of the experience.

As stated above, the underlying premise of "flipped classroom" is that students review lecture materials outside the classroom coming to class ready to participate in learning activities, therefore the experience has been designed following the three distinctive times of the flipped classroom, defined as follows: "Before Class" and "After Class" which take place remotely and "During Class" which takes place in the classroom in the presence of the lecturers. The module makes use of the social media tool "Slack" as a digital platform to share with students the learning material. It both guarantee a common thread through the activities in the classroom and remotely, keeping a continuity of learning, and facilitate the collaborative work using a social language suitable for a new generation of learners.

We have therefore worked on three specific levels: ***acquisition of the basic notions of DT,*** exploration of ***group dynamics and process facilitation between peers,*** and ***development of soft skills*** useful for the process (creativity, problem solving, communication, etc.)

In order to reach the learning goals, the activities and the specific tools have been designed considering what the student should perform before, during and after the lesson, also assigning an estimated time for each activity. We planned in details the in-class learning activities and the pace to be kept as well as the learning activities to be performed outside the classroom, to be realistically quantified with respect to the overall commitment of the student. The whole DT process is therefore practiced collaboratively during the in-class activities once individually explored in remote through the didactic material prepared and shared by the research team.

The next sections discuss the setting of the experience. For the sake of clarity, the designed activities are described through the chosen learning engagement strategies.

30.4.1 The Flipped Classroom Design Framework: Experiential Learning

We designed a creative learning experience, based on the "flipped classroom" approach and problem-based approach with role-playing activities to explore the Design Thinking (DT) process and tools.

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Read-Write-Pair-Share

A first peer-review activity allows an overview of the DT process. In this scenario, we divide learners into teams giving them three questions: 1. Find the most exhaustive definition of Design Thinking. 2. In what kind of field is applied and why? 3. Find three successful cases of application.

The students are given quiet time (30 min) to search and write the answer. Students are then cued to discuss their responses, noting similarities and differences. It is important to give students enough time to share what they found and decide a common answer to the 3 questions. After this task students are invited in 2 minutes to share publicly using a slide.

This activity lets students start from a common background of the DT process, its tools and its practical application.

Team Role-Play

The didactic experience has been developed considering the integration of role play as game mechanisms to involve people in active collaboration, deep immersion and reflection (Simsarian, 2003; Canina and Bruno, 2018).

Three roles have been defined to create the right conditions to generate debates, lead reflections and thoughts, collect and reelaborate insights, and to ensure active collaboration, both in class and out of class.

The 3 roles are those necessary for a design team that has to solve a collaborative design challenge.

- Facilitators: make the collaboration easier for the participants supporting the team working at its best. They have to learn how to manage the activities Before the class design session and facilitate them During class.
- Researchers: workforce that will bring information about the topic key insights to the table. They have an independent role of research Before the class activities and report to the Slack Guardians. They also have a collaborative and active role During the in-class design session.
- Slack Guardians: guide the community and manage the communication with the team, Before and After class activities, through Slack. A Slack Guardian keeps the conversation about the different topics going, asks trigger questions that can help the Researchers to stay on the right track and suggests sources of inspirations such as interesting links, new tools or case studies.

For each role precise instructions have been created to carry out the "Before", "During" and "After" class activities, explaining the meaning of their role,

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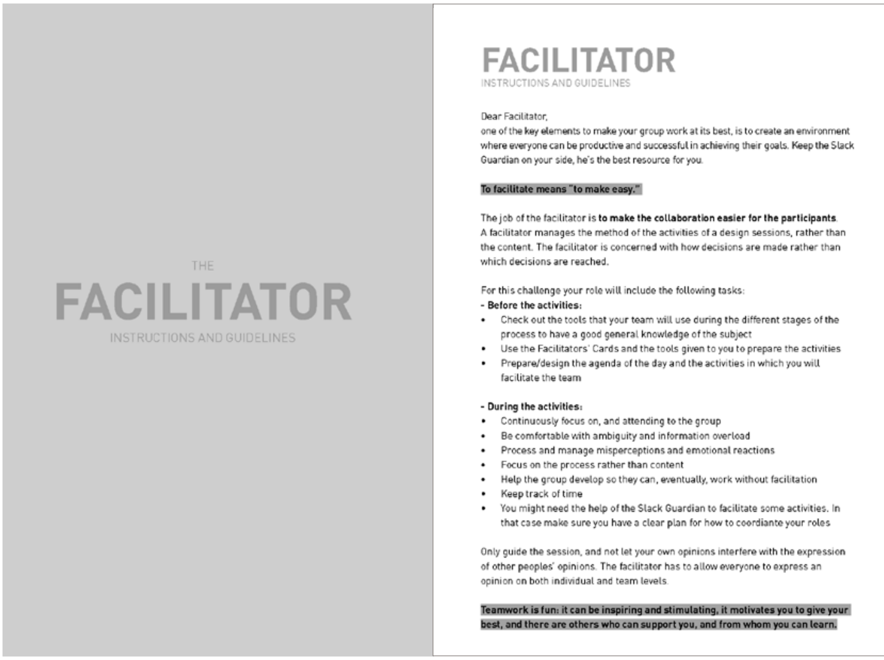

THE
FACILITATOR
INSTRUCTIONS AND GUIDELINES

FACILITATOR
INSTRUCTIONS AND GUIDELINES

Dear Facilitator,
one of the **key elements** to make your group work at its best, is to create an environment where everyone can be productive and successful in achieving their goals. Keep the Slack Guardian on your side, he's the best resource for you.

To facilitate means "to make easy."

The job of the facilitator is **to make the collaboration easier for the participants**.
A facilitator manages the method of the activities of a design sessions, rather than the content. The facilitator is concerned with how decisions are made rather than which decisions are reached.

For this challenge your role will include the following tasks:
- Before the activities:
- Check out the tools that your team will use during the different stages of the process to have a good general knowledge of the subject
- Use the Facilitators' Cards and the tools given to you to prepare the activities
- Prepare/design the agenda of the day and the activities in which you will facilitate the team

- During the activities:
- Continuously focus on, and attending to the group
- Be comfortable with ambiguity and information overload
- Process and manage misperceptions and emotional reactions
- Focus on the process rather than content
- Help the group develop so they can, eventually, work without facilitation
- Keep track of time
- You might need the help of the Slack Guardian to facilitate some activities. In that case make sure you have a clear plan for how to coordiante your roles

Only guide the session, and not let your own opinions interfere with the expression of other peoples' opinions. The facilitator has to allow everyone to express an opinion on both individual and team levels.

Teamwork is fun: it can be inspiring and stimulating, it motivates you to give your best, and there are others who can support you, and from whom you can learn.

Fig. 30.2 - The role instruction cards

the didactic material available and the interaction with the "Slack" tool and the fellow students.

Flipped Classroom

The activities planned for the Explore and Generate phases have been divided into two consequential blocks so that each stage has a "Before Class" time for preparation and learning, a "During Class" time for practical activity and reflection and an "After Class" time for feedback of the work.

The exchange of roles among the learners in the explore and generate stages is required to allow all the participants to perform differently the collaboration within the teamwork, either as the facilitator who manages the team and leads it to achieve the objectives throughout the whole process or as a researcher or community manager (Strayer, 2012).

Before class. This is the moment when the learner studies and reflects autonomously on the didactic material provided by the lecturers through the digital platform.

The didactic material includes role instructions, learning materials, tools and guidelines aiming at preparing the learners in putting the process in practice during the in-class activities according to the pre-established roles. The Facilitators receive the role instructions and the "Activity Cards" which explain in detail the objective of each activity, how to facilitate the group during the activity and the results to achieve. For each activity, a collection of design tools is made available as well as a collection of learning materials. They also receive an agenda of the activities to fill in by selecting the most suitable tools manageable from them in the provided collection.

The Researchers received specific instructions for their role and a series of tools and guidelines which support them in their research activity before delivering in the classroom. The correct performance of this activity guarantees good results especially in terms of solving the design challenge.

At this moment of the didactic experience, the Slack Guardians have the fundamental role of managing the learning inside the digital community, by making the participants able to reflect on the didactic material provided, on the ongoing results of the design challenge, enabling them to develop critical thought. This role is fundamental because it guarantees the correct preparation of the participants in view of the activities in the classroom. They receive through the Slack channel instructions and stimuli on how to conduct their activity.

During Class. This is the moment in which the learner actively puts its acquired knowledge into practice, reinforcing it with the support of the lecturers. The activity in the classroom is carried out like a real session of collaborative design. The participants, each one with its own role, are working in teams, previously formed.

The Facilitator has the task of introducing the activities to the group, carefully explaining their objective, the ways of carrying them out and the result to be obtained. One after the other, the activities are carried out by the group under the guidance of the Facilitator with the support of the Slack Guardian. They should put the Researchers in the conditions of using the prepared and selected tools for the activity, sharing with them the knowledge acquired and enabling their creativity to solve the design challenge.

The team is constantly followed and supported by the lecturers/tutors who provide the roles with tips and insights to best carry out the activity. They guarantee efficient learning by supporting the teams in forming a well-established and cohesive group, suggesting activities (ice-breaking and energizers) that create a favourable creative climate, and encourages a team spirit and the sharing of objectives. They also support individual learning by a debriefing at the end of the activities, to reflect on the work done.

After Class. Learners reflect autonomously on their classroom experience, providing feedback on the results obtained in the collaborating phase and sharing it through the dedicated Slack channel.

The channel is the box keeping of the learning journey that allows for an in-depth reflection of the achieved results and of the critical points throughout the whole process.

30.5 Conclusion

An in-depth reflection on the designed module is necessary regarding the complexity of the process and the amount of teaching material. The learners' main difficulties were in understanding the mechanism and rules of the flipped classroom and in selfmanaging the teaching material provided.

They appreciated the in-class interactive activities which put their creativity and their intelligence at the centre. Compared to traditional DT training, the flipped module has the potentialities of giving learners more responsibility for their learning experience providing them with well-structured guidance to facilitate the DT process driving their peers in the development of a design project. The personal interaction motivates students and engages the entire class. This module takes the advantages of problem-based learning activities developing learner's problem solving, critical thinking and decision-making skills, encouraging critical reflection and enabling the appreciation of ambiguity in situations.

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31. Universal Distance Design for Accessible Radical Collaboration in Education

by Amy Kern

Abstract

This research proposes an online framework and a set of strategies to overcome current limitations in preforming ethnography for design projects in higher education. This paper reviews how collaborative design ethnographic research, interpretation and reflection is sustained and extended by digital tools, ultimately creating a living archive of data that can be analyzed and grown within the framework.

The paper reaches the conclusion that digitizing the experience of design ethnography makes it more accessible, systematic, and layered for in-depth insight mining for designed objects, spaces, and services within a semester's course. It is especially suited towards culturally specific design projects and increasing the potential inclusiveness and value in universal and human centered design projects.

Keywords: *Co-creation, Design ethnography, Team ethnography, Digital tools, Digital research, Distance design, Cultural sustainability.*

31.1 Introduction

This paper outlines an interactive online framework for design educators to use in scaffolding cross cultural co-created design projects digitally using the internet's available tools and platforms to preform design ethnographic studies remotely – a concept called Distance Design here. The focus on team ethnography and how it can be shaped by the digital realm forwards an understanding of how Distance Design can be a powerful pedagogical tool especially relevant to design students and projects.

Design today is breaking down borders: national, material, and inter personal. "*The seismic shifts taking place in every industry demand a new design practice: collaborative but in a way that amplifies, rather than subdues, the* *creative powers of individuals*" (Brown, 2009). Increasingly, offices reflect this mindset as flexible shared work spaces prove a favorable alternative to closed door offices. Additionally, in greater numbers, virtual online spaces are where people go to shop, be entertained and even make new friends. Distance learning is a growing business especially for non-traditional students who often struggle with dedicating time and money for continued learning. Design education should be first to embrace non-traditional students who can rely upon a breadth of human experiences to enrich their Design Thinking. However, online courses which work well for other disciplines commonly are done in a vacuum with little interaction or opportunities to practice all important collaborative and hands-on design skills. The proposed framework would structure an experience for students of design that encourages co-creation across teams and cultures while simultaneously builds a dynamic archive that will inspire more "emotionally durable" and culturally sustainable design.

31.2 Core Learning Objectives and Theoretical Outcomes

Whenever possible, collaboration face-to-face is preferable for most design projects but there are significant benefits for students when conducting research remotely that can be derived precisely because of the challenges of designing at a distance, not in spite of them. Framing the experience in a global realm will further prepare students to navigate the international industry expectations of design. Designers are tasked with designing products, services, and places to be as "universally desirable" as possible in an effort to command a larger market share. Carefully matching online tools with design research objectives can open the world up to students who may not have ample resources to travel readily available. The proposed model is a hybrid that leverages the positive learning objectives of face-to-face and remote research.

Collaboration is key in the design world. The days of egocentric design are falling away to co-creation and genuine teamwork. "*Team ethnography is not just a change of scale; rather, there are differences between the processes... that affect all stages of an ethnographic project*" (Jarzabkowski, Bednarek and Cabantous, 2015). Managing the division of labor amongst the team is crucial and addressed with the Distance Design interface. The dynamic of a multisited team scenario engages students to productively collaborate and promotes collective sense-making across languages and cultural differences.

The value for students of design when immersing themselves into a culturally specific collaborative design endeavor is threefold. First, invariably the student practices human centered design researchmining for insights and usability cues that would resonate and appeal to their chosen user group and hence, move away from design choices that are akin to designing for people instead of designing more universally with people. Secondly, designing research protocol to be effective remotely is a unique challenge that requires the student to use tools creatively and learn to avoid common research pitfalls which are more plentiful and less error tolerant than in other primary research. In fact, the research projects that will feed this framework will mandate considerable critical thinking in preparation and implementation for their overall success. Students need to find project appropriate probing questions and information gathering techniques that will not bias results, a crucial skill for design research and an especially delicate one across cultures. Thirdly, lessons of cultural sustainability are increasing relevant for designers. Understanding the far reaching consequences of how design choices impact communities is an important concern. Responsible engagement is paramount and might ultimately serve to counteract some ill effects of globalization. "*The use of a society's cultural factors in design not only makes technologies more appropriate for their social context, but makes better use of culture itself as a resource for innovation*" (Moalosi *et al*., 2005).

31.3 Experimental Foundations Point to Solutions

Two retrospective case studies are described here to better understand the value and obstacles of team ethnography, immersion into fieldwork, and collective interpretation. If the existing challenges can be mitigated with Distance Design then cross cultural design ethnography can be more widely embraced in academia. Additionally, virtual tag-team ethnography may be a way to bridge co-location issues without compromising valuable results. "*Field notes can be produced, shared and commented on collaboratively, in real time or in near real time, and independently of the researchers' locations*" (Beneito-Montagut, Begueria and Nizaia, 2017).

In the spring of 2017 and 2018, precursors of the proposed theoretical framework took place with students collaborating on different projects from different design schools consecutively in different countries. The single team formed each year was interdisciplinary and comprised of industrial design, engineering, and architecture students – 10 from United States and 10 from Germany. The team worked together on a single design that would be integrated into the hosting institution's campus, then the team (changing membership only slightly) went to the reciprocating country the following year so those team members could then become the hosts for a similar site-specific design installation.

Each design was expected to reflect that campus' culture and aesthetics, available materials and equipment, and conceptually be a physical artifact of the collaboration itself. A sparse brief was given so that the participants would have to negotiate and deliberate on product specifications and work on navigating expectations. Each student brought a unique perspective and so ample time (at least 30% of the project time) was dedicated to exploration and meaning definition to resolve language and cultural barriers.

These case studies inspired some of the specific choices in the design of the proposed new framework. They took place extracurricular, and so increased financial stresses and disrupted the student's semester. By integrating the experience into existing courses towards their degree, we can theorize that the students can focus more on the particular project and process.

If the short time constraints (two weeks or less), jet lag and social dynamics are taken away, you remove many of the most nuanced obstacles. It may indeed be the stressors that heighten the international experience, but simultaneously they may be precisely what diminishes the probability of data driven design results. Removing these barriers in Distance Design allows for a deeper systematic investigation because it requires a predetermined and agreed upon distribution of responsibilities and a more distilled research approach applied and well documented.

The case studies showed that co-creation across cultures was realistic and exciting for the students. However subsequent interviews revealed that challenges included team building, establishing accountability and maintaining conversations and contributions throughout every stage of the project even after the time together ended. Students would tune out or be intimidated if they didn't feel like they could contribute to the same degree as their peers. Therefore, the results lacked refinement and upon completion the students were not motivated to reflect on ways to continue development which is important for industrial design. To mitigate this, the alignment of research goals and expectations is critical. Distance Design would support this by ascertaining project specifics including student research and design skill levels and manage availability of the students in the form of time tokens. Each team will be given virtual tokens and they decide how many they want to allocate to each phase of the research. That way no team can dominate the attention of the other team without consensus. This also works as a kind of budgeting so students can see if their return on investment makes sense moving forward.

These strategies help clarify roles so the co-creation experience is balanced and fair and still continues to celebrate the best of cross cultural design collaboration.

31.4 Digital Tools May Bridge Gaps

With the effectual use of extant digital tools and platforms filtered through the Distance Design framework, educators will be able to streamline the learning experience to make it exponentially more advantageous for everyone involved with greater transparency and accountability. Consider how social media and online collaboration and sharing tools have transformed the digital landscape and what they can do for design research education. Observation and digital journaling become more powerful and shared with a smartphone and YouTube, team building more efficient via Skype, questionnaires made easy with Survey Monkey and soliciting wider perspectives from massive global audiences is available to anyone with an internet connection. Since much of the onsite research happens based on direction remotely, subjects tend to reflect genuine core values without excessive direction and expectations from the in-person researcher. The researchers are also less likely to overlook an insight or misinterpret the results because they didn't have cultural relativism or critical distance. Distance design inquiry will theoretically transform how designers ask questions and prioritize and validate the responses, it might also change the very questions student researchers need to ask. These digital methods can yield copious data quickly across various cultures. Students, therefore, would certainly need to methodically practice identifying trends and patterns to sift for design insightssatisfying a core learning objective. Even something as traditional as scrapbooking becomes more fertile when Pinterest or Instagram is used to start online visual boards specific to the design inquiry and built in analytics might provide additional data.

Each of these digital tools require careful handling when used to gather primary qualitative or quantitative research. It is vitally important for design educators to teach the consequences of wrongly assuming that the self-selected populations that engage in them necessarily represent the community of users the design students wish to reach. The perceived anonymity created by digital ethnography encourages participants to write more candidly, but again, this appeals to a particular set of the population. Therefore, genuine collaboration needs to be introduced into Distance Design by educators to help facilitate field research and interpret the findings. It is in the act of delegating this part of design research that will teach students to reflect on the pros and cons of using any particular tool over another based on the research project goals and target users. Also, collaborating with design students closer to the culture they hope to engage becomes an invaluable conduit for profound cultural exchange. Field notes need to be systematically shared and since they can be subjective to the first-hand observer, open dialogue for interpretation is encourage. Managing the project so that the interaction feels mutually beneficial and productive gives students some exposure to developing team dynamics across varied mindsets and skill sets.

Standard ethnographic tools can also breach the barriers of long distances with a little help from technology. Cultural Probes, Vox Pops or Sensory Postcards take advantage of people's preexisting or provided access to smartphones to record short video messages that capture auditory and visual moments in the "day in the life" of real users in the users' real context, voice and time. Now, these recordings can be shared almost instantly by the subjects themselves. Observational research videos and recordings of interviews made by the local design team would augment the relevant data. This type of eth nography across time, language, and space traditionally would take weeks and significant support to perform in person and could still be biased by the designers own cultural lenses.

The Distance Design interactive platform will archive the results of any research activities automatically and document all collaboration in the form of real-time entries and comments. This would give the team members and the overseeing educator complete and timely transparency. Conventionally, data would be reported on after the point course corrections are viable, conversely the digital living archive has check points every step of the way.

31.5 Theoretical Logistics

Student design teams of any manageable size and demographics would self-identify their skill levels, communities they have contact to, and time constraints. Based on these factors, a collaboration is negotiated between two design teams. Each have access to specific communities and each design team creates investigation and testing protocol plans which the collaborating team will carry out within their community affiliations. Any available tool that is deemed appropriate can be specified to gather the most useful information in the time allotted for the project. The design teams report back the results with digital tools and help to interpret the findings. They each act as research consultants for the other team and then reciprocate. The artifacts of this collaboration are archived and formatted for easy searching and can be calibrated to welcome an extended community for their comments and contributions if desired.

By delegating the in-person field duties of research to another team, the design teams must proceed with caution to avoid confusion as they collaborate with the team that has "boots on the ground". Together the two teams find the best protocols for their goals that might work best for the communities being reached. Since one team has an in-person relationship with the community and the other has a vested interest in the outcome of the research, the collaboration is both motivated and fruitful, especially since it is directly reciprocated. Switching hats from "community expert" to "design lead", the students are empowered to use the same thoughtfulness that they expect from the other team, therefore uniting the traditional hierarchical split between data collection and data analysis. All team members are then encouraged to annotate and comment on the field notes and media artifacts using their own experience in the field and from their unique perspectives. This ongoing interpretative layer provides an open platform for radical collaboration and reflection.

31.6 Conclusion

If educators broadly define culture as any community, any group of people at all, then these projects inherently fall under the human centered design umbrella and inclusivity. Human-Centred Design projects challenge students to gain a deeper understanding of user's predilections, attitudes, and values and encourage them to find strategies on how to use culture as a resource in product development for all kinds of designs. Completely scalable, the project framework and learning objectives introduced here work on any timeline, product category, community characteristics and level of education. Eventually, the matching of teams to other teams and communities to projects would happen through the platform, enabling educators to focus on nurturing the interactions and outcomes. Until the community of users on the platform is varied enough, the educators would need to create relationships with other teams across universities and academic departments.

Sustainability in design generally fall under the headings of people, planet and profits. Cultural sustainability is particularly relevant in designing in Human-Centred Design since it involves the way potential users perceive a design. "*The problem is that the more culturally shallow things are, the less of a real and enduring connection people have with them*" (Lockhart, 2017). By investigating these connections, students can design with them in mind so that they increase the "emotional durability" of their designs. If the connections can be strengthen, along with intelligent choices in materials and manufacturing processes, then the longevity of the product is improved. The aim of design ethnography is to achieve deep understanding and insights into the people and places of product use. Enabling students to preform cross cultural design research in an organized way will serve to empower design students to be more global in their user centered designed projects with fewer barriers.

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32. Teaching UD in Different Curricula and Professional Areas

by Isabella Tiziana Steffan

Abstract

Teaching offers the possibility of sharing a common understanding, spreading not only theoretical concepts, but also projects, implementations and good practices to different profile of students.

The dissemination of the Universal Design Principles is a fundamental requirement for the development of an aware and effective approach to the issues of sustainability and social inclusion.

Both in the university and professional fields, it is possible to increase knowledge and awareness of the importance of an approach aimed at satisfying different needs. Teaching in almost all European Counties is often not enough to cover such a complex issue as Universal Design.

This paper will compare a range of educational experiences from several courses in different curricular areas, such as: Degree in Architecture, Degree in Tourism Science and local Communities, Degree in Communication Theory and Techniques, and vocational training in Ergonomics and Human Factors.

It will also examine the teaching methods, the problems encountered and the factors that allowed to achieve better results in terms of awareness and application of the knowledge acquired. In fact, there is a serious lack of basic training and the tendency to consider the UD a minor and sectorial specialisation, and not an essential planning approach.

A specific training is important, in order to assimilate the different concepts of a design for specific needs, and a Universal Design.

Keywords: *Teaching UD*, *Different curricula*, *Refreshes courses*.

32.1 Introduction

In the UN Convention on the Rights of Persons with Disabilities (CRPD), accessibility and Universal Design is specifically required.

Universal Design is also called with different terms such as Design for All and Inclusive Design.

In the European Disability Strategy 2010-2020, in accordance with UN CRPD, the European Commission aims to use legislative and standardisation tools to improve accessibility for people with disabilities, and launches a series of standardisation mandates, which in turn have led to some standards, that emphasise the Design for All approach.

The term "Universal Design" is widely used at international level, while the European Union prefers "Accessibility with a Design for All approach". It is crucial to be aware that: Universal Design and Design for All share a similar Inclusive Design philosophy; "Accessible design", "Barrier-free design", "Inclusive Design" etc. are often used interchangeably.The dissemination of Universal Design/Design for All Principles is a fundamental requirement for the development of an aware and effective approach to the issues of sustainability and social inclusion of all people, including those with disability, children, elderly. This approach is totally different from the design for disability or the design for special needs, that is focused on specific requests. Teaching offers therefore the possibility of sharing a common understanding of these approaches and terminology, and spreading not only theoretical concepts, but also projects, solutions, implementations and good practices to different profile of students.

32.2 Background and Objectives

This paper compares a range of educational experiences of different universities: some from the Politecnico di Milano for the Master's Degree in Architecture, at the Department of Architecture Building and Enviroment Engineering; other from the Università degli Studi Milano – Bicocca for the Master's Degree on Tourism Science and local Communities at the Department of Social studies and for the Master's Degree on Communication Theory and Techniques at the Departments of Psychology and ICT, as well as courses with different curricula such as Interior Design, industrial design, graphic design, fashion, communication, held at the European Institute of Design.

This paper compares also some refresher courses for professionals and employees of companies with different background that include, among others:

- different courses for architects at Universities of Architecture of different towns in Italy;
- annual courses for therapists focused on technologies for inclusion organised by Fondazione Don Carlo Gnocchi and Università Cattolica in the past 20 years;

- vocational Masters on Ergonomics organised by different Institutions in collaboration with SIE Italian Association of Ergonomics and Human Factors, in different towns in Italy;
- innovative international workshops organised by private associations, focused on: designing toys for All (e.g. by Foerdern durch Spielmittel-Spielzeng fur behinderte Kinder e. V. from Berlin together with other Associations from all around the world in ten years) and focused on strategies/actions to be led by professionals, decision makers and stakeholders (e.g. by Info-Handicap from Luxembourg).

It is possible to identify some main common objectives among these teaching experiences, namely:

- to explain and promote the UD/Design for All approach both in university education and in professional refresher courses, in different curricular areas;
- to highlight the positive social and economic effects generated by the application of UD;
- to demonstrate that it is appropriate to apply design principles from the beginning, and not as an adjustment during the execution or post-implementation phase;
- to raise awareness on the fact that regulatory tools are fundamental for the design but are only the starting point for a truly inclusive project;
- to share concrete examples where UD is applied;
- to develop and share moments of creativity and collective planning, involving decision-makers and real users;
- to demonstrate that some solutions found to give answers to special needs can often fit a wide range of users.

32.3 Methodology

The methods used to achieve the aforementioned objectives were different, depending on the duration of the courses and the participants.

32.3.1 Basic Common Methods

Courses aimed at university students, professionals or public employees have always included:

- **Lectures**. Front lessons, with the following contents: design for disability/design for special needs; Universal Design/Design for All approaches; definitions of terms; explanation of the "Seven Principles of UD" associated with concrete examples and best practices; presentation of the legislative developments at local, national and European level, in parallel with the historical and social evolution; explanation of the importance of direct involvement of end users, tests and ongoing and final checks.

- **Direct Testimonies of Stakeholders and Decision Makers.** Everyone is different from anyone else, but also from himself in the course of life, for physiological, pathological, psycho-social reasons. The knowledge of different experiences, told by those directly involved, is decisive in trying to understand the problems, needs and demands, not always expressed, of people with temporary or permanent disabilities. Direct testimonies of people with disabilities and representatives of associations are crucial to understand users' real needs. Participation of decision makers such as entrepreneurs, companies, representatives of public bodies is also important (Fig. 32.1). The meeting with representatives of associations or renowned professionals have often become open lectures or public lectures in universities, aimed at widening as much as possible the dissemination of the issues addressed.

- **Experiential Moments of Direct Involvement with Simulation of Disability and Observations.** Students and course participants have experienced the disadvantages of a built environment that is often not attentive to everyone's different needs. Thanks to the collaboration with local associations, it has been possible to tackle an urban path in order to personally experience the interaction with architectural, social and cultural barriers. Using a wheelchair to experience motor disability, wearing special glasses or a bandage to experiment with different visual impairments, wearing ear tips to simulate deafness, becomes for a while the personal experience of each participant. The urban and architectural tours included a critical analysis, a graphic and oral presentation that was shared and discussed with the group of students (Fig. 32.2). Students of Degree courses in Psychology, Sociology and Tourism Sciences have also managed the reservation by phone call or e-mail to a hotel or restaurant, simulating a person with a disability, to ask for information regarding the service and structure. They asked e.g., for different dietary requirements, presence of steps or elevators, dimensions and equipment present in accessible bathrooms or rooms, etc..

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Fig. 32.1 - **Direct testimonies of a blind person.** Università degli Studi Milano-Bicocca

Fig. 32.2 - Experience on wheelchair, together with a blind teacher. Politecnico di Milano

32.3.2 Additional Methods

On several occasions, additional methods have been introduced, such as:

- **Direct Experience of Blindness in Total Darkness.** Special participation in "Dialogue in the dark" was possible, for courses in the Milan area, at the Institute of the Blinds in Milan. This exhibition allows to experience how the perception of reality and communication can be in conditions of absence of light. Opened in December 2005, it differs from a traditional exhibition due to the total absence of light and the fact that visitors, in order to explore the environment, must rely exclusively on the senses of touch, hearing, smell and taste. In groups of up to eight people, visitors make a journey through some settings that recall everyday life situations, all different, to be discovered through the senses and dialogue with the blind guide, revealing "another way of seeing". After having crossed the different environments, the last stage is a bar where, always in total darkness, the experience is commented. Dialogue in the Dark is not a simulation of blindness, but the invitation to experience how the perception of reality and communication can be much deeper and more intense in the absence of light.

- **Debate on Temporary/Permanent Disability and on the Different Aspects of Accessibility.** The awareness of future expert professionals goes through the awareness that "*disability is a handicap only if the project has not taken it into account*" (Steffan, 2012): anyone can happen to have a disability, permanent or temporary, in the course of life, be it an arm in a cast, the fear of using a lift, of not being able to understand direction road signs, or the banal forgetfulness of wearing glasses with you. Course participants, especially if they are young, do not always have direct experiences of friends or family with disabilities, and it is therefore appropriate to highlight the peculiarities inherent in each disability in order to promote the effectiveness of a design (of product, service, environment, software) that best responds to the greatest possible number of needs. The aim of the debate was to raise students' awareness on temporary and permanent disabilities, and on the different aspects of accessibility by inducing critical observation of a known environment, e.g. within family, school, work environment.

- **Practical Exercises.** The course participants were asked to identify suitable tools to detect problems and potential, to develop innovative and inclusive solutions. The most used were questionnaires, interviews, user tests aimed at analysing the interaction between user and the built product/environment.

- **Development and Review of Group Projects.** The development of a specific project, or the application of the principles of Universal Design in an ongoing laboratory project, allows a direct confirmation of what has actually been implemented, and of how it is simpler, more effective and more economical to apply the UD principles from the early stages of project development, and not during the implementation phase – or having to adapt the project later on.

32.3.3 Methods Dedicated to Professionals

Moreover, in courses aimed at professionals, we can mention:

- **Guided Visits to Buildings/Places.** On several occasions, such as participation in workshops organised by associations, companies and work groups, there was the possibility not only to exchange opinions between experts, but also to participate to guided visits in different european towns, where UD design methods and solutions were adopted. The aim was to share good practices among professionals, that can be of inspiration. The information received is generally used in seminars and subsequent lessons, in the perspective of lifelong learning.

- **Creative Product/Service Workshops.** Participation in creative workshops allows experienced and non-expert professionals to directly

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experience the needs and aspirations of real users, in close contact with the people directly involved. Examples were the series of international and UNESCO workshops organised by "Forden durch Spielmittel-Spielseng fur behinderte Kinder e.V" for designing, developing and testing Toys (Lastrico and Steffan, 2001) and the Segni Seed, an urban project to develop a small community in the province of Rome (Fortuzzi, Serafini and Steffan, 2014).

- **Professional Workshops.** Participation in professional workshops allows to share information, methods, strategies and design process. The main aim is to network different associations that represent different users, and to establish connections between associations, final decision makers and public administrations, that is the main characteristic of the UD/DfA approach. The methodological good practices are shared by expert professionals from various countries and pertaining to different specialisations, who can thus testify in their workplace the advantages of the networks of associations and the comparison with the public administrations. Examples include the eMpower Workshop in Luxembourg "Municipalities enabling the citizens" by Info-Handicap (Lucchini and Steffan 2013) (Figs. 33.3, 33.4).

Fig. 32.3 - Visit to Belval by train. Luxembourg

Fig. 32.4 - Experience of a cruise along the Mosella river in an accessible ship, the Princess Marie Astrid. Luxembourg

32.4 Results and Teaching Developments

There was considerable interest from all learners, and the desire to apply the UD approach in their own professional fields. They also have:

- developed a better awareness of the needs of diversity and social inclusion, both in terms of orientation and mobility, and in terms of accessibility and usability;
- understood the importance of the application of the UD and DfA principles from the early stages of the project, and not as a subsequent correction solely aimed at getting adapted to the legislation;
- understood the transversality of accessible design and the various sectors of possible application (built environment, private and public products and services, etc);
- understood the opportunities offered by the tourism and cultural sectors.

In addition to the immediate results of the course, thanks to the interest aroused, there were further requests for additional study and application developments. In particular:

- several dissertations have been developed in different Degree Courses (e.g. Architecture, Industrial Design, International Master in Structures and Technologies in Architecture, Communication Theory and Technology, Tourism Sciences and Local Community). In the Thesis "Urban quality and Design for All", written in English by an Afghan student of the Master in Structures and Technologies in Architecture, Department of Structural Engineering, Scuola Fratelli Pesenti, the principles of UD and DfA have been developed in an intercultural perspective;
- a course-laboratory of Architecture in which the UD/DfA themes have been introduced, has led to the activation of a post-graduate internship on the theme "Design for All in public residential buildings", called "Build for all, Design for All and environmental sustainability in public buildings. The case study of the towers of Via Tofano 5 in Milan", for a student at the House and Property Department of the Technical Area of the Municipality of Milan. This involved several municipal technical sectors, promoting a new attention to the needs of users, in addition to the mere reduction of compliance with current regulations. A group of students developed the examination project, and presented papers in scientific congresses (e.g. IX national congress of SIE Italian Society of Ergonomics and Human Factors in 2010);
- to supplement some university courses, public lectures were organised, including one with Prof. Simon Darcy, from the University of Technology Business School, Sydney, and that of the UIA-AfA group Architecture for All working groups of the International Union of Architects "Accessible Architecture in Expo Times" during Expo 2015 in Milan. Public conferences have proved to be a very useful tool for expanding the dissemination

of UD and DfA issues not only in the academic or specialist fields, but also among decision makers and citizens.

32.5 Issues

Based on the teaching experiences described above, it is possible to identify some critical points for the understanding and future application of the UD approach by the learners.

It was found that many university students, even in the last years of their course of studies, had never faced the problems of an inclusive project, and some of them had little information even on the elimination of architectural barriers and on the legislation for accessibility, which should be for all designers an essential starting point for quality design. This denounces a serious lack of basic training.

There was sometimes a certain difficulty in understanding that:

- the UD/DfA approach cannot be effectively applied without first knowing the needs of the individual user profiles (people with temporary or permanent disabilities, elderly, children, foreigners);
- UD/DfA is not synonymous with the sum of different disabilities but, similar to the ergonomic approach, considers the interaction between user and object/product/service, also taking into account the instances of people with temporary or permanent disabilities;
- some problems are common to different courses, both in mono-disciplinary university courses (e.g. Degree in architecture) and/or intercultural (with students from different countries), and in professional refresher courses (for example vocational masters);
- despite the great interest and sensitivity of the learners due to their ethical and social aspects, a certain difficulty was found in understanding the complexity of the UD/DfA approach as the basic preparation is different depending on the individual academic and professional path, cultural background, age;
- specific disability courses and workshops are useful for understanding the needs of real people, but, nevertheless, they are likely to be considered as the point of arrival, rather than the starting point of the U/DfA approach, useful for better understanding specific needs and taking them into account;
- short seminars included in a general course often do not get the desired results. This is because it takes a certain path and a certain amount of time in order to take in the basic concepts of design for special needs,

accessibility and design without barriers, and then move from the concept of design "without barriers" to the concept of a Design for All;
- there is also the tendency to consider the UD/DfA a minor and sectorial specialisation, and not an essential planning approach, as it takes into account the needs of all possible users of products/environments/services.

32.6 Conclusions

Learners generally understand and appreciate the ethical and social importance of inclusive projects. They develop a better awareness of their social role, in order to improve participation in social life.

Learners have recognised the advantages of an accessible project in the various areas, covering many aspects, including opportunities in the tourism and cultural sectors, the built environment, products and services, both in the private and public sectors.

Learners found more difficult to implement the UD principles from the early stages of the project and with the participation of all the actors involved, going beyond the simple application of the legislation.

Considering all that, it seems very important to assimilate first the different concepts of a design for special, specific needs. Then a paradigm shift is needed: the transition from a "category of people" approach to one for "user profiles", from "features" to "needs and expectations".

Considering the lack of basic training found, and the tendency to consider the UD/DfA a minor and sectorial specialisation, instead of an essential planning approach, it is also essential to teach the UD philosophy starting from primary schools. This is important for additional follow-ups, in different curricula, to train not only architects and urban planners but also professionals in all sectors such as tourism, communication and management.

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33. A Framework to Support Inclusive Design Teaching and Product Evaluation: Application in Overcoming Barriers in Food Preparation for Elderly Visual Impaired People

by Gloria Gomez, Sarah Wakes

Abstract

The fundamental success measures for an inclusive product or service are functionality, usability, desirability and viability. Often in practice they are not all met. Students and academics need clear guidelines on how well designed concepts meet these measures, and address the needs and values of their users with impairments, carers, and families. This issue was identified as being particularly challenging in a non-immersive industrial design programme, for students of diverse backgrounds, that worked on a design project to overcome barriers in food preparation for elderly visual impaired people. To address these challenges, an evaluation framework was developed using existing knowledge and good practice on Inclusive Design, assistive technology and disability, living with vision impairment, and empirical data gathered via activities undertaken with elderly visual impaired people. This framework supports the teaching of Inclusive Design concepts as part of academic programmes designing aids for impairment or rehabilitation. To show how it works, the framework's five criteria are applied to a student design concept, summarised in table format, and accompanied by a descriptive analysis. This detailed information allows a decision to be made about as to whether a given design is socially inclusive or not.

Keywords: *Evaluation framework, Teaching Inclusive Design, Socially inclusive products, Assistive technology, Vision impairment.*

33.1 Background

Key Inclusive Design principles are still not being taught or applied as universally as would be ideal, leading to products and services that exclude sections of the population, are socially stigmatising, or do not integrate well into people's lives (Harris, 2008; Keates and Clarkson, 2003; McAdams and Kostovich, 2011). The fundamental measures of success for an inclusive product or service, functionality, usability, desirability and viability (Clarkson *et al.*, 2007) are often not all being met. Students and academics need clear guidelines on how well design concepts meet these principles and address the needs and values of their users with impairments, carers, and families (Dong, 2010; Harris, 2008; McAdams and Kostovich, 2011). This issue was identified as being particularly challenging in a non-immersive industrial design programme with students of diverse backgrounds (Gomez and Wakes, 2017).

We developed an evaluation framework to support the teaching of Inclusive Design concepts, developed from a project with visually impaired people (VIP), to develop concepts for assisting food preparation. The framework aims to: 1) enhance the applicability of key Inclusive Design concepts, 2) guide students, teachers, and the impairment community in the assessment of potential solutions, and as well as 3) address three problematic situations encountered in the teaching of Inclusive Design.

Research shows that relevant stakeholders acknowledge the importance of designing for inclusion (Harris, 2008; Keates and Clarkson, 2003; McAdams and Kostovich, 2011; United Nations, 2006). However, the lack of knowledge within business regarding the practice and resources of Inclusive Design is a major obstacle for wide adoption. Easy to apply methods are needed to facilitate its adoption (BSI, 2005; Ferri, 2015; McAdams and Kostovich, 2011; United Nations, 2006) in teaching, training, and professional design activity.

Article 26(3) of the Convention on the Rights of Persons with Disabilities says, "*States Parties shall promote availability, knowledge and use of assistive devices and technologies, designed for persons with disabilities, as they relate to habilitation and rehabilitation*" (United Nations, 2006). This framework may help to achieve the Inclusive Design goal, which is to meet the needs of consumers of diverse age and capability in a wide range of contexts because appropriate access to information, products, services, and facilities is a fundamental human right (BSI, 2005).

33.2 Method: Framework Development

The framework was developed in response to three problematic teaching situations first encountered when the Inclusive Design concepts were taught in an industrial design class (as part of a non-immersive design degree) in 2012. These were:

1. students found difficulties engaging in an integrated system perspective,

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meaning that could not relate the potential solutions to the everyday living of the elderly VIP and their families;
2. students struggled to apply key Inclusive Design concepts in a design process that also included the application of other design methodologies and methods relevant to an industrial design paper (i.e. Design Thinking, sustainability concepts, Ergonomics, etc.);
3. disagreement on the "goodness" of a design concept during assessment by academics and the user community, due to conflicting evaluation requirements. The elderly VIP found simple designs good, while the academics felt these were not developed to a high enough level.

To address this situation, a framework with five criteria sets was developed based on theoretical and empirical sources taught as part of a lecture on Inclusive Design, a lecture on living with vision impairment as an elderly person, and semi-structured interviews with a group of elderly VIP. These activities were undertaken as part of the study programme of the industrial design paper. The criteria sets aim to facilitate the evaluation of a design concept from multiple perspectives, and assess if it meets the fundamental measures of success of an inclusive product or service (i.e. functional, usable, desirable, and viable).

The development of criteria 1 and 2 came from interaction with users and their lived experience with the impairment, and ensures some user contact in a project via primary and/or secondary sources. The development of criteria 3, 4, and 5 are non-specific to a particular impairment and come from theoretical and good practice sources in disability, assistive technology, and Inclusive Design (i.e. concepts, benefits, principles, recommendations) that students were introduced to as part of lectures.

Caveat. The criteria set might feel like a formula that it is static and predictive, but it is not. Instead, it provides the foundation for creating a substantial empirical base that can be relied upon. Its empirical qualities, and the sources that inform it, will only improve with its application and dissemination.

When used, these criteria are compared against ideal values for each item established in the framework. Therefore, if a concept solution addresses most or all of these items, the design can be considered socially inclusive for the particular context and group of impaired users. It is adaptable for product/service design focused on other impairments by replacing the facts on user background and associated impairment issues in criteria 1 and 2.

Through the application of the criteria to a process of early concept development, the framework has the potential to enable inexperienced people to gain knowledge on the practice and the resources of Inclusive Design. The outcome, a socially inclusive product, requires engagement with the user community and their environment via primary and/or secondary sources (Clarkson *et al.*, 2007; Keates and Clarkson, 2003), often a challenging aspect of the design process. The framework could be applied to work towards the advancement of any product/service idea, from ideation to proof of concept, with any impairment, over several iterations with incoming student cohorts. User communities could use it to evaluate solutions already in market. It could be adapted for commercial design development, or it could serve an important role as a reminder for any designer of the needs of the client/user, when there is limited contact with impaired users.

33.3 Results: Applying the Framework

Student groups in a 2012 industrial design paper developed four design concepts for preparing food as an elderly VIP. The concepts were a milk pourer called "Milk Aid", an electronic system for scanning, recording, and measuring called "Kitchen Hand", an oven interface, and an educational resource called "Blinkers". As part of the framework development, the authors undertook a retrospective evaluation of the student designs. The evaluation of "the Milk Aid" serves as an example to show how the framework is applied, and assessment of whether a concept solution may (or may not) help elderly VIP regain a level of independence in food preparation.

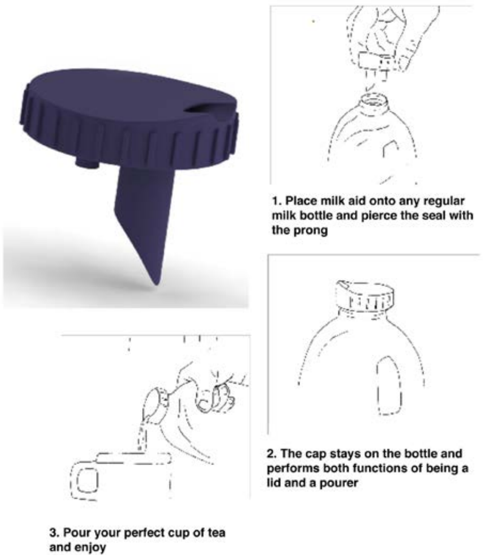

Fig. 33.1 - Milk Aid

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The "Milk Aid" is a device to fit on a bottle that delivers a single measure of liquid (Fig. 33.1). It addresses one procedure, "pouring milk", as part of the basic operation or activity "making a hot drink". It may enable elderly VIP to fulfil a basic and nourishing need with independence and safety, and therefore, regain some quality of life.

Tab. 33.1 - Summary of values met for criteria 1 and 2

CRITERIA 1: QUALITY OF LIFE WHILE LIVING WITH VISION IMPAIRMENT	Values met Milk Aid
Keep nourished	YES
Regain social independence	YES
Regain establishing social relationships	YES
Regain functional ability such as enhanced mobility	YES
Regain the ability to care for oneself	YES
Prevents psychological implications such as depression	YES
Prevents early admission to nursing homes	NO
CRITERIA 2: DESIGN NEEDS IDENTIFIED BY THE ELDERLY VIP	
Supports the activity of consuming food	YES
Utensil	YES
High contrast colours	NO
Tactile cues	YES
Safe easy to remember cooking routines	YES

Criteria 1 covers "quality of live while living with vision impairment", developed using a secondary source – the Global Mapping of Low Vision Services (Chiang, 2009). This design meets most items in these criteria, apart from "prevents early admission to nursing homes" (Tab. 33.1).

Criteria 2 covers "design needs identified by the elderly VIP", which were the result of a brainstorming activity in class, from primary sources – activities with the VIP. Most criteria were met, except one "high contrast and colour" (Tab. 33.1).

The physical prototypes, used at the student presentation of their design, enabled visualisation of how the pourer could work and to imagine the product in their kitchen. The VIP said they liked the concept as it solved a basic problem for them, was simple to use, easy to understand, and had one use only. This simple straightforward physical product could allow VIP to retain some independence. Being able to make a drink and pour milk into a cup does improve quality of life, albeit in a limited way.

Criteria 3 was sourced from a study on benefits of minor and major adaptations in a living environment as reported in the World Report on Disability (World Health Organization, 2011). This design meets the items in criteria 3 (Tab. 33.2).

The "Milk Aid" addresses the physical barrier of having trouble seeing the level while pouring a liquid, which is a small task in need of attention according to the VIP. This minor solution/adaptation could not only promote social inclusion, but also reduce strain on professional or informal carers by relieving them from undertaking small tasks such as this one, and bring some independence back.

Tab. 33.2 - Summary of values met for criteria 3, 4, and 5

CRITERIA 3: BENEFITS OF MINOR AND MAJOR ADAPTATIONS	Values met Milk Aid
Users were carefully consulted	YES
The whole family needs were carefully considered	YES
The integrity of the environment (i.e. kitchen) has been respected	YES
Reduces strain on carers	YES
Promotes social inclusion	YES
Justifies investment in health and rehabilitation resources (e.g. product development)	YES
CRITERIA 4: AVOIDING EXCLUDING TECHNOLOGIES	
Uncomplicated design	YES
Perceptible information	YES
CRITERIA 5: KEY CONCEPTS FROM THE INCLUSIVE DESIGN APPROACH	
Sub-criteria 5a: Countering design exclusion	
High demands to other capabilities	YES: Touch
The inner circle can continue to use the kitchen (e.g. carer, family and friends)	YES
Minor and major adaptations fit within the existing kitchen set up	YES: minor
Sub-criteria 5b: Type of Inclusive Designs	
Special purpose design	YES
Sub-criteria 5c: User social acceptability attributes	
The product stigmatises a VIP in any way	NO
The VIP want this product	YES
Sub-criteria 5d: User practical acceptability attributes	
Usefulness	YES: Utility

Criteria 4 was sourced from a study in which 46 people with diverse impairment were interviewed in-depth on the impact of advanced technologies in their lives (Harris, 2008). A visual analysis of the design (Fig. 33.1) determined that two items in criteria 4 (Tab. 33.2), "uncomplicated designs" and "perceptible information", are met.

Criteria 5 was concepts sourced from the Inclusive Design Approach (Keates and Clarkson, 2003), organised into 4 sub-criteria (Tab. 33.2). This special purpose design (5b) is a minor adaptation countering design exclusion (5a), with low impact in the kitchen environment and for other people in the inner circle. Having high capability demand on touch, it might exclude elderly VIP who also have a dexterity impairment, unless this issue is address explicitly in a design process. It does not stigmatise VIP who also want the product (5c). Through inspection of the prototype, they found that the "Milk Aid" could solve a basic problem in an easy and simple manner. Because of this, it is possible to evaluate its "utility" – an element of the usefulness attribute (5d). The implementation of a tangible working model is required for undertaking studies and explorations to evaluate most items in criteria 4 (e.g. "low physical effort") and all items in sub-criteria 5c and 5d, covering user social and user practical acceptability attributes.

Further design work is needed to address customisation (only one size of measured dose), mobility issues, only fitting standard bottles, and the issue of hot liquids or spillage. It might need to be evolved into a pourer that works with different kinds of bottles, or thinking about pouring out of Tetra Pak containers. These aspects should be studied and explored in an iterative process with the guidance of criteria 4 and 5. In terms of the fundamental measures of success for an Inclusive Design product, this design concept meets the desirability and functionality measures (criteria 1, 2, 3, and sub-criteria 5a), but does not yet meet in full the usability and viability measures (criteria 4 and 5).

33.4 Conclusion

This Inclusive Design framework has enhanced the applicability of Inclusive Design concepts. Its application on a design concept demonstrates that this early design is on the way of becoming a socially inclusive product that could enter the everyday living of elderly VIP with no dexterity issues. The framework acts as a checklist for keeping track of learning and embedding knowledge and application of Inclusive Design concepts and user needs.

At present, the framework is being applied in two different design courses. The first one is an immersive industrial design bachelor in Colombia. Fourth-Year students are applying the framework to group projects in rehabilitation design. The second one is part of a non-immersive design programme in New Zealand where postgraduate students of diverse science backgrounds are applying the framework to individual projects in bioengineering design. In both teaching situations, the framework is used at the start, during, and at the end of the design process. The lecturers have developed their respective methodological approaches for teaching their courses, and are using the framework as an instrument for evaluating the social inclusivity of the design outcomes. The data gathered will be used to analyse if the aims of the framework are met: (1) stimulate empathy in a novice designer and the novice designer with the user; (2) capture user needs, desires and values as well as key Inclusive Design principles; and (3) be used as an evaluation guide for students, teachers and users at any stage in a design process.

Other applications beyond teaching can be foreseen. Evaluation of solutions already available in the market are undertaken to guide users and stakeholders in a purchasing process. Designers (novice or experienced) apply it to the evaluation of a gap in the market as part of a commercial product development process.

Finally, there is a plan to use it in the development of gamified assistive technology for online academic study (Contreras, Gómez and Navarro-Newball, 2019).

Acknowledgements

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34. Parameter of Inclusive Design for Spaces of Learning: New Methods in Design Education

by Ulrich Nether, Jan Phillip Ley, Johanna Julia Dorf, Kristina Herrmann

Abstract

In Germany, we are facing a radical growth of the necessity for inclusive school environments due to the regulations of the National Action Plan (NAP 2.0) of Germany's Federal Government (2016)[1] that is based on the UNConvention on the Rights of Persons with Disabilities (UNCRPD). A recent study (Kricke *et al.*, 2018)[2] shows that Inclusion in the context of learning environments works the best if it's part of a holistic concept including interior architecture as the common ground for equal learning experiences.

To give design students a tool to develop a professional position towards Universal Design and Inclusion we generated Parameters of Inclusive Design for Spaces of Learning, which were tested and re-evaluated in an international student workshop as part of an ERASMUS+ project called "PUDCAD". The first results show that such tools can help students to overcome the equation of Universal Design with accessibility in order to create spaces that can shape a socially sustainable future respecting the idea of diversity.

Keywords: *Universal Design, Inclusive Design, Design Education, Spaces of Learning, Interior Architecture.*

34.1 Introduction

We are convinced that interior architecture plays a significant role in social interactions in everyday life. Working on the topic of Universal Design, we experienced a limited understanding of the reach of Universal Design ideas in our field of expertise.

Designers and design educators often underestimate its relevance due to the equation with accessibility. This can lead to a focus group that is limited to people with permanent disabilities, which affect motoric functions. Can we expand this scope to include every user by introducing a user spectrum clustered in "permanent, temporary and situational" disabilities to use the full potential of inclusive thinking (Microsoft, 2016)[3]?

Encouraging the motivation in future designers to become caretakers of Inclusion in design and design research tools like "The Principles of Universal Design" (NC State University, 1997)[4] can serve as an objective baseline for a universal approach in design education. Nevertheless, they are not sufficient in terms of empathy and openness towards a broader user spectrum. We need new strategies that serve as catalysts for a process of rethinking and even more so establishing the idea of Inclusion.

For the specific context of learning environments, we developed the Parameters of Universal Design for Spaces of Learning (Parameter) to empower design students to create socially sustainable design concepts that include everyone. Those Parameters were discussed and re-evaluated within an international student workshop during the Universal Design Practice Conference 2018 as a part of the ERASMUS+ project called "PUDCAD Practicing Universal Design Principles in Design Education through a CAD-based game". The project is related to one of the foremost priorities of the European Commission: to provide accessibility and Inclusion of people with disabilities into everyday life. It aims at students learning and practicing their Universal Design knowledge and skills through an empathetic approach.

34.2 Background

"PUDCAD" is an international project which is fundet by the European Erasmus+ Program and started in the year 2017 and will end in 2020. The aim of the PUDCAD Project (Practicing Universal Design Principles in Design Education through a CAD-based game) is to develop a game, a platform, where students (architects, designer, engineers) can improve their knowledge about Universal Design and get more sensitive and empathy, playfully, in the topic of Universal Design and inclusion. With this knowledge, the students have the opportunity to transfer all the information in their own projects.

The coordinators of the project are the ITU, Istanbul Faculty of Architecture, Turkey. The other project members are five universities and two partners: LAMK (Lahti University of Applied Sciences) Finland, UNIFI (Università degli Studi di Firenze) Italy, POLIMI (Politecnico di Mailo) Italy, the "Association for Well-being of Children with Cerebral Palsy" Turkey, BAU (Bahcesehir University, Turkey), TH OWL (OWL Technical University of Applied Sciences) Department Architecture and Interior Architecture, Germany. The organistation SERCEV

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(Association for Well-being of children with Cerebral Palsy) and the "Occupational Therapy Association of Turkey".

These three project years are structured in several activities, international student workshops and international conferences with expert talks and interdisciplinary and intercultural exchange for people with and without disabilities and Transnational Project Meetings. In these different activities, the project is processed and further developed in different ways. All activities take place in a diversified way in the partner universities.

The first student workshop in Mai 2018 took place at POLIMI (Politecnico di Milano) Italy. The workshop involving 25 students from the five different partner universities. In five international teams, they had to develop innovative design ideas according to the Universal Design principals. The knowledge of this workshop to create concepts with the "7 Design Principals of Universal Design"[5], raised the question, if there are no other parameters to consider, which are helpful to make inclusion and Universal Design comprehensible.

In the following semester in an elective Modul at TH OWL, students developed together with Jan Phillip Ley 7 Parameters. These were developed by different approaches, like the empathy trail. Where the students try to put themselves into the situation of a person with a physical limitation by e.g. wearing an ageing suite. These user scenarios or case studies, were carried out at two schools in Detmold. After the elaboration and analysis of these scenarios, the Parameters were developed, which will be explained in detail below:

34.2.1 Parameter

It is not only important to teach skills on how to design but also to teach an understanding of the impact every design has. The spaces young designers develop shape the social interactions of everyday life. As educators, we have to provide the tools for a responsible cooperation between designers, potential users and the environment. Talking about Inclusive Design, we want to introduce three key elements that are important within every design process: how emerged?

- Understand diversity as a tool to design spaces for social participation! Physiological attributes, individual abilities, needs as well as personal experience add up to the way we perceive our surrounding environment. In order to create the architectural frame for a social coexistence that respects the individual, we have to design spaces that trigger empathy.
- We are all handicapped![6] A design of spaces, objects or media environments that is excluding cannot only become a barrier for people with

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"permanently" limited abilities, for instance people in a wheelchair, it can also reduce the qualities of interaction "temporary" e.g. if you have a broken arm, or "situational" if you want to pass a door with a cup of your favourite tea (Microsoft, 2016). Universal Design should include all kinds of circumstances.

- Create Access! Therefore, we have to understand accessibility not only as a spatial but social parameter in order to create diverse atmospheres that motivate for appropriation to trigger processes of identification. Universal Design has to equally create access to health, mobility, knowledge and social interaction.

1. **Well-Being**. In the context of school environments, well-being is not only a question of health, personal care, nutrition and hygienic standards, acoustics or natural light but also a social question. We can learn that the way we design spaces or objects and its interactions not only involves physical aspects but also affects the process of developing and strengthening an individual personality.

2. **Organisation.** In order to navigate through a room, known or unknown, we must be able to sense its affordance. Information systems should enable a multisensory experience to be useful for everyone. A clear structure with a generous and simple design language is necessary to secure high functionality for heterogeneous user groups. The organization of spaces always affects social interactions.
   A spatial network with clear connections between inside, outside and in between its microlayers creates an open architecture that serves as a base for the large spectrum for a variety of learning formats. Transparency in the architectural language creates transparency in communication that supports equal learning.

3. **Communication.** Different kinds of people use different ways to communicate: spoken language, written words, signs, gestures or facial expressions are used to make the other understand our objectives. Designing multisensory experiences, different people with different abilities can adapt to, will help to create the architectural foundation for sharing knowledge and experiences regardless of the social or cultural background and cognitive or physiological abilities. This architecture must tolerate differences in its usage by providing different layers of information to be sensed by everyone. Regarding the variety of its user groups learning environments must offer a variety of different species of spaces for communication.

4. **Transformation.** Our goal is to create spaces of transformation that empower people to act self-sufficient and self-confident developing individual interests and a feeling of responsibility for their environment as well as empathy for others.
   Learning environments should offer a variety of spatial constellations that help different users gathering knowledge by sharing experiences with respect to their specific skills and abilities.
   The use of digital tools and technology can help to indentify, developing and communicating knowledge. It supports the individual by extending specific abilities.

5. **Creativity + Collectiveness.** Creativity is important to develop a striving, inquisitive and mindful personality. Therefore, the process of learning should not only be a process of thinking but equally a process of making. By the use of colours, haptic materials and natural light creative spaces of learning evolve to multisensory environments with diverse atmospheres. Flexibility and improvisation can create an open architecture that still gives enough space for appropriation and individual development. It makes the user learn how to overcome physical and mental barriers to create a feeling of belonging, which generates collectivity and thereby multiplies creativity.
   Cooperation means teamwork on all levels. It rejects hierarchies that usually result in boundaries, which have to be turned into fluid membranes to enable trustful relationships and collective growth.

6. **Action.** The design of dynamic architecture helps to increase the user's mobility. On the one hand, we guarantee accessibility by a strategically smart organization of spatial relations, the creation of movement zones, and circulation areas with appropriate dimensions. On the other hand, we use design components that support an active, dynamic and flexible use. Thinking in motion creates progress.

7. **Diversity.** Inclusion can only be achieved by understanding the potential of diversity. School architecture becomes a place for equal learning if it enables heterogeneity by respecting individual abilities, needs, desires and fears. Culture and personal experience shape us in the same way the design and the use of spaces affects what one could call identity. Spaces of learning should not only teach knowledge but also self-respect and respect to the other. In that sense, Inclusive Design can become a place for individuation.

34.3 Method

34.3.1 Workshop

The Parameter we developed served as a starting point for the 2nd international Student Workshop and Conference "Universal Playground" engaging the 30 participating students, which formed in 5 international teams from all five involved universities. The workshop is from Monday to Thursday and the final conference on Friday. The Student Workshop consisted of five parts: to think, to analyse, to prototype, to digitalise, and to communicate and discuss with and about people with diverse abilities.

Additionally, we provided the possibility to gather knowledge and experience on the topic of Universal Design and Inclusion, create an inspiring workspace, by the use of modular furniture, to get in contact with people with different abilities and learn new tools to create innovative ideas and Inclusive Design solutions for spaces of shared knowledge.

For that reason, we set a design research task at the learning space that is our university campus. To test and re-evaluate the Parameter, the students had to work through a particular design research process and apply one given Parameter in a specific spatial scenario.

Accompanying those activities, several "Input Sessions" provided inspiring ideas and fundamental information for the students. In two "Network Sessions", we invited experts from different fields of design and education to give an insight into their professional and personal experiences with and without a disability.

As a succeeding step to previous results from a first workshop in Milan, Italy, the corresponding "Universal Design Practice Conference 2018" was dealing with new strategies of thinking and prototyping, which can create places of common learning for everyone. Following the baseline ideas of Universal Design, those places not only facilitate Inclusion but also promote diversity.

The week was focused on the international student workshop "Universal Playground" with the aim to discuss the new approaches towards clustering the focus group and explore the use of the Parameter.

Each of the five workshop days had a driving motive which leads through the design research process:

Embodied Thinking. Every design task starts with contemplating the topic. Since thinking is easier if our body is part of it, we created a variety of active board games that encouraged the students to brainstorm fresh ideas and help situate their given Parameter.

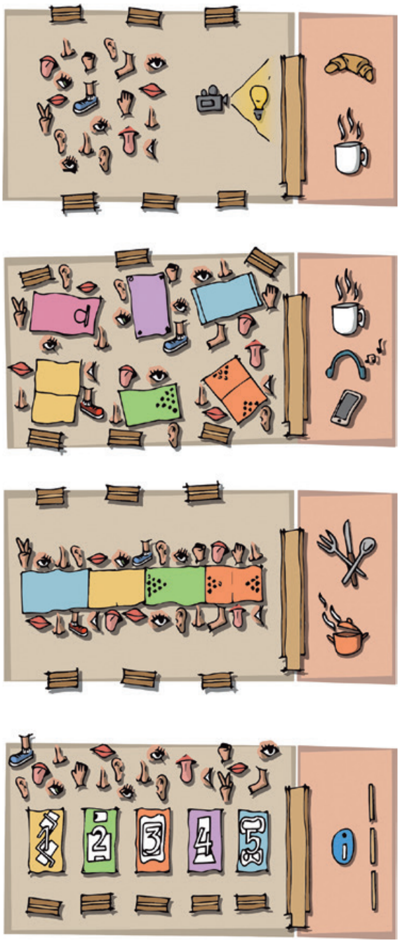

Fig. 34.1 - Graphic of transformative potential of the workshop space in four variations: presentation, group work, dinner and exhibition

Figs. 34.2, 34.3 - Student-teams brainstorming with the game board.

Figs. 34.4, 34.5 - Groups collecting and discussing sensory research results

Figs. 34.6, 34.7 - On-site prototyping

Sensory Research. A structured analysis can be enlightening if our senses are involved. We provided a collection of analogue and digital tools for the students to conduct and evaluate a perception-based analysis of specific spatial locations in relation to their Parameter on our campus. Decisive for this procedure was to empathize with three fictional personas with "permanently, temporarily or situationally" limited abilities (Microsoft, 2016).

Plaything Experience. To experience our research playfully and tangibly we needed it to have an actual shape. The students used basic materials e.g. cardboard in order to build a 1:1 prototype as a tangible reference of the given Parameter. Two objectives were to be complied with: first of all, a specific use that was related to the location as well as considering the needs and abilities of the fictional personas. Second, the prototype was to embody the brainstorm and research activities as a spatialized metaphor of the Parameter experienced as a haptic object.

Virtual Playground. Next, we involved innovative digital tools to expand the user's sensation as well as to get a better understanding of the perceptions

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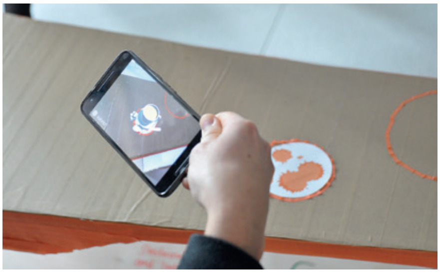

Fig. 34.8 - Students testing their interactive AR applications

Figs. 34.9, 34.10 - Visitors contemplating the 1:1 prototypes

gathered during the research process. Together with experts for digital media, the students involved new technologies like augmented reality (AR) that helped to digitalise the prototypes and enlarged the tangible objects by the virtual world, utilizing miscellaneous data they generated in the research phase of the workshop.

Universal Playground Exhibition. The last and most significant step was to communicate our findings regarding the Parameter. The design research process was reflected together with the whole workshop team and a concept on presenting the results as a holistic and atmospheric exhibition evolved. Multisensory realtime environments were created by adding digital sounds, videos or animations to the analogy world creating an engaging exhibition as well as creating access for people with different kinds of abilities. The Exhibition conveyed the message of the prototypes and enabled the visitors to comprehend the students' approach to design research.

34.4 Results

During the workshop, we always used the Parameter as a starting point for the design process. Working with only the given Parameter without further requirements and the general context of learning environments the students

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searched for corresponding locations and next included specific interactions and activities. Two of the groups showed especially profound results:

Parameter Action. Proceeding from the Parameter Action this group developed five design criteria through an elaborated examination of our description in connection to their own brainstorming results. For them, the term action consisted of freedom, companionship, flexibility, fun and subtlety. These criteria lead the students to an outside space on our campus for which they developed the specific use “cultureaction”. The object they designed was to give the opportunity to be a meeting and orientation point and a space for spontaneous lectures. By extending the physical object with a digital layer that can be activated through an AR application, a public sound library for teaching and an outdoor cinema and a place for music were implemented.

Interesting about this process was that the exploration of the Parameter extended with the analysis of the chosen location helped them to even add to it in their way. The term “action” was enhanced with the social character of “culture”. This guided them to come up with a distinct design language in their build object that enables the users’ potential to create inclusive environments for multisensory experiences and social interaction.

Parameter Transformation. The Parameter Transformation helped the students to transfer the classical concept of their brainstormed activity “teaching” to an innovative understanding of learning involving the group’s design criteria:

Fig. 34.11 - Storyboard for different use-cases

Fig. 34.12 - An AR-App extends the object to a tangible media environment

change our thinking, opportunity, accessibility, connectivity, tools. The object facilitates an innovative system for different formats of typical teaching and learning activities. The main goal of the object was to trigger a different way of thinking on the terms of teaching and learning. By inventing a foldable system that serves as wall elements, displays or seating they created an inclusive environment with high transformative potential. Space becomes a tool to provoke a change in thinking that generates diverse types of communication. This supports the formation of a personal approach towards learning assignments and gives space to strengthen individual skills, interests and social competences.

34.5 Conclusion

Through our re-evaluation process, we established that the Parameter of Inclusive Design for Spaces of Learning are indeed useful as a teaching tool in terms of designing inclusive environments that go beyond Universal Design. The first step of working with it as a method was the general use without a specific design problem. In the next step to further test their benefit, they are to be applied to a specific design task with predetermined requirements. Additionally, they could be useful as a validation tool for existing learning environments.

Even without previous professional knowledge design students can use them methodically to generate spatial solutions that have an inclusive effect on user interaction. Within a short amount of time students can find an appropriate design language to rethink, disrupt and in the end, manifest revised common values. Furthermore, they find their standing regarding empathy and openness towards a broadened user spectrum starting from ther individual perspective. Through new design methods, they can learn from embodiment to create a value of proximity and the sense of one's own body to trigger the social production of space.

Beginning with learning environments, a transfer of the Parameters of Inclusive Design can enrich human interactions in other fields of design as well. Therefore, design education has to underline the meaning of caring by establishing a holistic Inclusive Design practice, which should involve inclusive thinking concepts as well as participatory methods like co-creation and Human-Centred Design.

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35. Requirements for Inclusive Experiences in Design Knowledge Transfer

by Daniele Busciantella Ricci, Michela Ventin

Abstract

Implementing the European Action Plan for Design-Driven Innovation at a local level requires inclusive praxis for design knowledge transfer. The Design Research Lab (DRLab) at the University of Trento (Italy) has the mission to facilitate the transferring of design knowledge to the local systems in Trentino. DRLab designed and experimented a dissemination framework to be provided where service design is not systematically adopted. According to the design experiences (DXs) developed in collaboration with local design partners not trained in design, more than 150 people of very different age and from different backgrounds were engaged in collaborative design-based activities. By the analysis of the DXs as case studies, and data gathered from the participants, a set of requirements is identified for designing and developing inclusive DXs with the purpose of disseminating basic design knowledge. Finally, the paper provides a discussion on issues about (a) implementing inclusive approaches in multidisciplinary research contexts; (b) promoting Inclusive Design principles to local stakeholders; (c) orienting the service design process through a "design for inclusion" approach.

Keywords: *Design for inclusion, Service design, Learning by doing, Complexity, Design Thinking, Public policies.*

35.1 Introduction

Implementing the Action Plan for Design-Driven Innovation (European Commission, 2013) for the local development requires to influence as many actors as possible in the local systems, through taking into account that not all the entities and organisations are ready to face systemic changes. This is even more complex in contexts where design, as a human power of conceiving, planning, making (Buchanan, 2001), is not systematically embraced. Therefore, actions of design knowledge transfer in these contexts require a particular attention in applying transferrable praxis through Inclusive Design experiences for "*as many people as reasonably possible […] without the need for special adaptation or specialized design*" (The British Standards Institute, 2005 in Clarkson *et al.*, 2007).

This paper focuses on the research activities of an academic laboratory engaged in design knowledge transfer to local entities. The laboratory provided Co-Design based experiences with the aim of introducing service design to the local systems. These design experiences (DXs) were analysed as a set of case studies. Through a gap analysis, the cases suggested the identification of critical areas and criteria for the development of the DXs. From these data a set of requirements for providing inclusive DXs for design knowledge transfer has been identified. This study is based on the early experiences of the laboratory in collaboration with local actors and more cases to be analysed in the same contexts are needed. Finally, the empirical experiences highlighted data for understanding how the local agents relate to service design, design for inclusion and collaborative approaches.

35.2 Background

Since 2017, Design Research Lab (DRLab) at the University of Trento (Italy) pursues the mission of facilitating the transfer of design knowledge to the educational, production, and public policy systems in Trentino. DRLab refers to design research (Archer, 1981; Findeli, 2010; Jonas, 2014; Manzini, 2015) as the main field of study adopting research through design (RTD) (Findeli *et al.*, 2008; Frayling, 1993; Godin and Zahedi, 2014; Jonas, 2007; Zimmerman, Stolterman and Forlizzi, 2010) as research approach, and service design as design discipline to be encouraged for local innovation in public and private entities and associations. During the first year of activities, DRLab designed and experimented on field a framework for disseminating the design culture in local contexts with the goal of encouraging the usage of human-centred approaches through service design. The framework is the result of an action-based research approach that follows four phases (Fig. 35.1): Engaging; Analysing; Applying; Evaluating.

Therefore, this paper focuses on the DXs experimented during the Applying phase with five local design partners engaged in different fields (Fig. 35.2) where service design is not systematically adopted. More than 150 people not trained in design, of very different ages and from different backgrounds were engaged in collaborative design-based activities.

Technically, a DX is a simulation of a Human-Centred Design process based on real users' data and tangible design outputs and it is provided through a learning-by-doing approach.

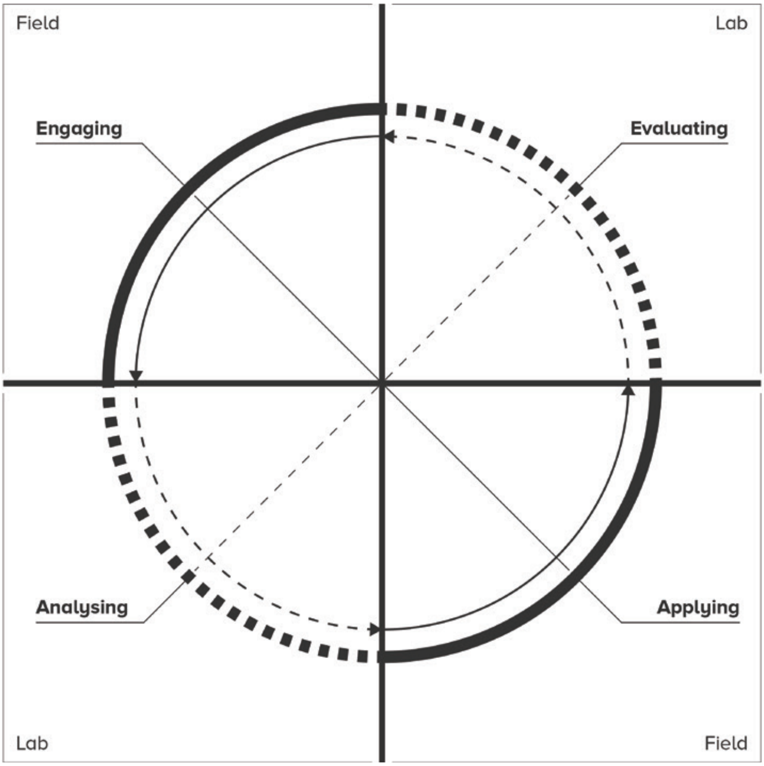

Fig. 35.1 - The DRLab action model

35.3 Methods

The experimented DXs were analysed as case studies (Fig. 35.3) and the more lasting ones were analysed with the Logical Framework (European Commission, 2004; United States Agency for International Development, 2012) matrix. The results were compared with the data gathered through the participants' involvement in focus groups, semi-structured interviews and anonymous questionnaires during the Evaluating phase. The comparison among these data was treated as an analysis of the gaps between what was planned as design formats and what was experienced as in-field activities. This analysis allowed the researchers to identify a set of discrepancies that were critically discussed, thus highlighting "crucial areas" and "criteria" for the DXs. These results were refined through an inclusive approach by taking into account Inclusive Design knowledge base (Dong *et al.*, 2015) references. According to this process, a set of requirements for inclusive DXs was identified.

DX1 DESIGN PARTNER: A local ICT company engaged in innovative Information Technologies **Typology:** Private entity	**DX1 SYSTEM:** Production system **DX1 ACTORS:** Company employers; CEO and managers; potential users
DX2 DESIGN PARTNER: A not-for-profit local association engaged in the valorization of the territory **Typology:** Public entity	**DX2 SYSTEM:** Public policies system **DX2 ACTORS:** Citizens; public admin. representatives; botanists; mentors; pro loco volunteers
DX3 DESIGN PARTNER: A provincial institute for research and educational experimentation **Typology:** Public entity	**DX3 SYSTEM:** Public policies system **DX3 ACTORS:** Teachers; students; parents; school directors; the Institute's representatives, the Employers' Association and the Department of Education and Culture of the Province of Trento
DX4 DESIGN PARTNER: A technical/technological educational institute (high school) in Trento **Typology:** Public entity	**DX4 SYSTEM:** Educational system **DX4 ACTORS:** Teachers; students; administratives (ATA); parents; school directors; representatives of IPRASE, the Employers' Association and the Department of Education and Culture of the Province of Trento; companies employers
DX5 DESIGN PARTNER: A trade association engaged in the food system of the Province of Trento **Typology:** Private entity	**DX5 SYSTEM:** Production system **DX5 ACTORS:** Bakers; consumers; sales personnel; representatives of the Italian General Confederation of Enterprises in Trentino (Confcommercio); experts in cereals foods and in bakery supply chain

Fig. 35.2 - The local design partners engaged for the DXs

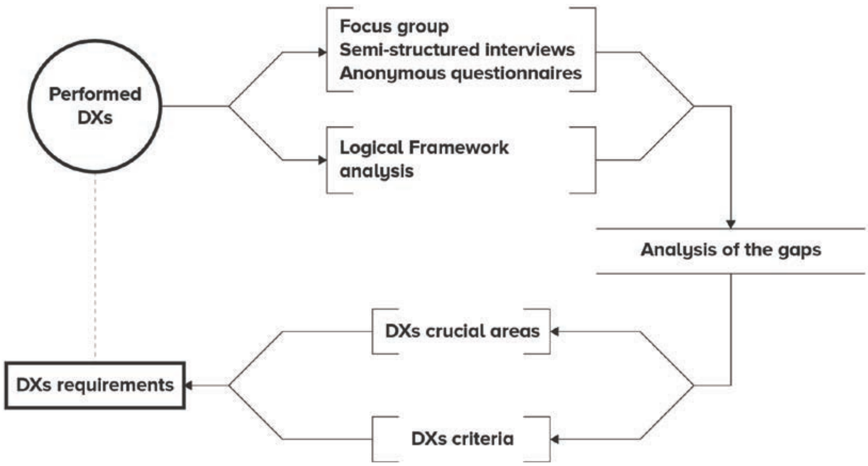

Fig. 35.3 - The methodological process for analysing the DXs

35.4 Results

The main result is a proposal for a set of interconnected requirements (Fig. 35.4) for designing and developing inclusive DXs with the aim of disseminating basic design knowledge to as many people as possible. The following paragraphs provide a description for every identified requirement.

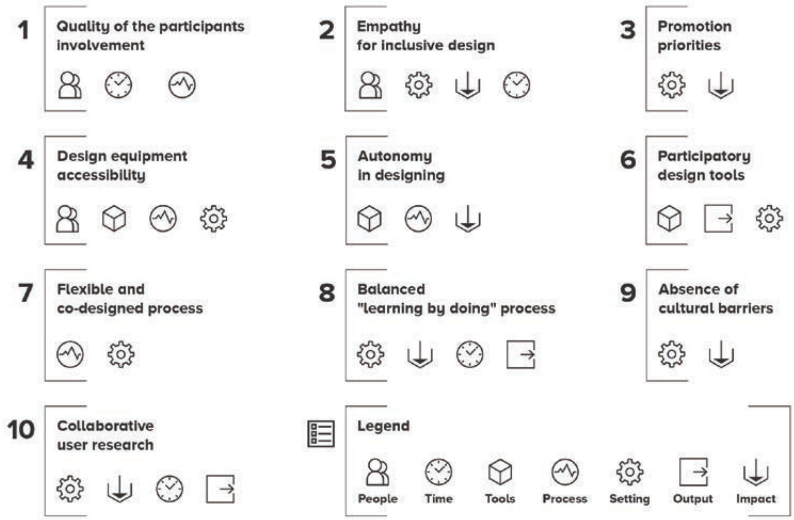

Fig. 35.4 - The set of requirements for inclusive DXs

Quality of the Participants Involvement. The gap analysis highlighted that some participants groups were not sufficiently representative of all the actors of the system. This because the involvement of extreme users, stakeholders at the edge of the actor maps and actors with specific needs was considered by the design partners as a factor that increases the complexity of the DX learning process. However, creating not homogeneous groups of participants among the system's actors is a requirement. Also, encouraging the maintenance of the heterogeneity in the groups is a central action during all the DX activities. Preferring the quality rather than the quantity is a priority and including extreme users, stakeholders at the edge of the actor maps and actors with specific needs is a fundamental aspect to improve the awareness of the actors' needs.

Empathy for Inclusive Design. Some gaps have shown the difficulties of the research team in involving the participants in all the collaborative activities. Therefore, creating the conditions for building empathy among the participants on inclusive and collaborative approaches before performing the DXs is a requirement. More than 20% of the total time of the DX should be spent with the design partners, before the DX core activities, for tutoring them about (a) the Inclusive Design principles; (b) the participative design approach; (c) the practical solutions for involving the actors of the system.

Promotion Priorities. This requirement (also related to the 35.4.1 and 35.4.2 paragraphs) describes the priorities in promoting the design knowledge contents. For an Inclusive Design knowledge transfer it is necessary that the main design approaches (e.g. Inclusive Design; participatory design) are promoted and transferred at a basic level before disseminating the design discipline principles adopted in the DX.

Design Equipment Accessibility. Despite the optimisation of the used design equipment for the DXs in an inclusive way, some gaps highlighted the participants' difficulties in understanding (a) the process and the tools in a systemic and holistic way, (b) the potentiality of the design results obtained through the use of the design tools. These gaps can be mitigated if the design process and tools are easily accessible, useful and fascinating especially for people (a) not trained in design and with different backgrounds, age, education levels, skills and attitudes; (b) without a remarkable design attitude; (c) particularly critical or discouraged by design practices.

Autonomy in Designing. The gaps described in the previous paragraph can be also mitigated by defining the objective of reaching the participants' autonomy in design. For applying this requirement (a) the design process and tools should be designed and transferred in order to encourage their usage in autonomy; (b) the impact of the dissemination actions should be constantly monitored in order to understand if, how and where the participants use the design processes and tools in autonomy, as well as how they were influenced by the promoted design approach; (c) the DXs should be considered as part of a lifelong learning processes for the participants.

Participatory Design Tools. The gaps presented above basically require that every design tool is designed or optimised to be used in participatory design activities by providing (a) templates of the design tools for facilitating the learning process; (b) tools that do not lose the main logic and efficacy although they are simplified and optimised for the usage in autonomy; (c) an adequate number of tools that do not overload the participants learning experience during the DX.

Flexible and Co-Designed Process. The gaps exposed in the 4.4 paragraph also suggest that the details of the design process of every DX should be always Co-Designed with the design partners and participants. If not possible, the Double Diamond (Design Council, 2007) can represent a reference to be promoted and customised before the DX with the participants. Also, the design process for a DX should follow "flexible rules" reaching a balance between a simplified, not-underpowered process, and an advanced detailed process.

Balanced "Learning by Doing" Process. The analysis of the gaps highlighted the participants' difficulties in the learning process due to the emphasis that was given to the practice through the learning by doing approach. Therefore, in performing a DX this approach should be balanced with theoretical activities. For this, in every Co-Design activity the time should be managed as follows:

- 25% for theoretical activities about the design knowledge contents;
- 50% for practice Co-Design activities;
- 25% for (a) analysing the design activity, (b) reading data gathered through the use of design tools, (c) contextualising the activity in the design process.

For more lasting DXs, 40% of the time should be spent in setting the experience before the core activities by considering the requirements above.

Absence of Cultural Barriers. A few gaps highlighted that, in some cases, the used terms and meanings from the literature in design created a sort of cultural barrier despite their previous optimisation for people not trained in design.

For this, terminologies and technical aspects should be always revised and simplified in order to break any kind of barrier. Specifically, all the contents should be exposed in the participant's mother tongue, and technical terms and advanced concepts should be simplified without losing the original logic and meaning.

Collaborative User Research. Some gaps highlighted the participants' difficulties in understanding how to manage and use the data gathered through the user research activities. Indeed, due to the lack of time and resources, the core design ethnography (Hanington and Martin, 2012) activities were performed by the design researchers of the DRLab. The participants were involved as subjects of the observation and as beneficiaries of the results. Consequently, the best condition for covering this kind of gaps is promoting, encouraging and performing user research activities as a fully collaborative set of actions for transferring the value of gathering user needs and empathizing with people problems. According to this requirement, the participants should have experience of the user research activities as "researchers" by the support of Co-Designed tools and practical insights.

35.5 Conclusions

This research work opened a discussion on three aspects that emerged from the empirical data which can represent opportunities for future inquiries.

First, the Inclusive Design philosophy in cross-disciplinary design research contexts is still an open challenge because (a) it is still perceived as an idealistic and utopian approach; (b) it is only linked to some specific disciplines such as product design; (c) it is considered as an approach that involves people with impairments and disabilities.

Second, the promotion of an Inclusive Design philosophy among the local stakeholders requires new strategies because (a) the concept of "designing" is not perceived as a collaborative process, but it is seen as a set of vertical relations where a client has a problem and a professional gives an answer; (b) the involvement of a wide range of actors with specific needs is still perceived as a "complication" for the whole experience; (c) someone still links "Inclusive Design" with design processes addressed to solve problems for extreme users and people with impairments and disability.

Third, service design principles – see Mager (2009) – consider participative and human-centred processes, that relieve the practitioners from the responsibility of a truly inclusive approach. Applying these principles is not enough for guarantying a full respect of the human diversity in the service design process.

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In other words, how can service design orient the process of designing through a "design for inclusion" praxis? This question could be the subject for future inquiry in the relations between service design and Inclusive Design.

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36. No One Excluded: Designing Multisensory Environments' Experiences for Children's Learning

by Giulia Cosentino, Mirko Gelsomini, Venanzio Arquilla

Abstract

The increasing debate about personalized and multimodal educational processes, arisen in the literature in the latest years, pointed out the noteworthy potentialities (Hwang, 2013) that an adaptive and synesthetic experience can have in helping children, especially those with special educational needs (Pares, 2005) improve their abilities. This work describes the design and development of Magika (Gelsomini, 2019), a multisensory and multimodal environment that incorporates digital world projected on the wall and on the floor with a large number of connected objects such as toys, ambient lights and materials that allow children to experience tactile, auditory, visual, and olfactory stimuli.

Multisensory and multimodal approaches are grounded on the theories of embodied cognition and sensory integration that emphasizes the formative role of embodiment – the way an organism's sensorimotor capacities enable it to successfully interact with the physical environment – in the development of cognitive skills such as mental imagery, working and implicit memory, reasoning and problem solving (Ayres, 1972). The variety of learning styles, methods and interaction paradigms that Magika provides, enables different levels of support for children with the most diverse attitudes, the result is a more balanced learning approach that leads to greater attention, understanding, comprehension, and retention (Fleming, 2001).

Magika's design started with a human centered design (HCD) approach, Co-Designed with more than 30 specialists at local care centers and primary schools and changed the role of teachers from being rather marginal as in current state-of-art solutions to be the core of a new accessible Co-Design process, considering all players' characteristics and needs in their singularity and diversity. To this extent, the system is connected to an interface for educators that enables them to control the level of stimuli and their progression; define and share a countless number of game-based learning activities; customize such activities to the evolving needs of each child. In particular, the customization process starts with an "onboarding" phase in which children are required

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to perform simple activities aiming at outlining their personal profile and suggesting the most suitable experience to be played, according to the profile of the player who interacts.

Magika aims at reducing the obstacles that children could encounter in key phases of their growth by recognizing and fostering children's inclusiveness, and less inconvenience for children and their families will experiment new educational and therapeutic approaches. Results from a preliminary exploration phase in 2 primary schools show the potential of using an HCD approach in enhancing children playful learning experiences. Combining multimodal interactions and strong personalization features, Magika offers unique ways of learning that have only been initially explored but have already shown its potential.

Keywords: *Multisensory environments, Education, Children, Disability, Personalized learning.*

36.1 Introduction

Nowadays, our society asks people with different abilities to adapt themselves to the social and physical environment and usually they are asked to make theirselves suitable to a system. As Designers our aim is to build accessible systems that allow them to minimize their efforts. In particular we built an inclusive environment able to transform a traditional classroom in a magic room; we first analyze current multisensory solutions and then highlights the entire process of a multidisciplinary team.

36.2 The Value of the Sensory Integration in a Learning Context

Today public school does not use a single approach or doctrine. The new didactic tendencies take inspirations from 20th century innovations. In this period pedagogy move to be an education science and two methods were relevant and are still significant today: Maria Montessori method (Montessori, 2013), present in Italy and in the world; and the educational approach developed by Rudolf Steiner (Steiner, 1996), more or less in the same period. Both methods consider the child in its complexity and completeness, with all his intellectual, physical and creative abilities. One of the inspirations behind comes from 1837, when Fredrich Frobel invented the "Kindergarten". This was a revolutionary approach, not only for childhood, but for descendants of all ages.

This learning style helps to develop the creative skills needed in this rapidly evolving society. Frobel took the distance from the traditional transmissive approach and opted for an interactive model, giving children the opportunity to collaborate with materials and objects called "gifts" and designed specifically in order to gives them the opportunity to develop a better knowledge of the world around them. While playing children learn how to elaborate their creative process, that can be describe as a "spiral of creative learning" (Resnick, 1998).

The "spiral of creative learning" is the engine of creative thinking. Nevertheless schools take the distance to this approach and they focus only on providing teaching through information. But play and movement are important aspects for children and in particular for children with disabilities that need different methods in order to learn and be include in the classroom.

These are essential aspects also for training sensory integration: another reason why children with disabilities, need enough time to design and experiment with new object and exercise their body. That's why provide students with opportunities for sensory experience enhances the ability of the central nervous system to process and integrate sensory information, so Multisensoriality become more effective than traditional training patterns.

36.3 Multisensory System

A multisensory system is an interconnected structure grounded on the theories of embodied cognition and sensory integration, on the development of cognitive skills such as mental imagery, working and implicit memory, reasoning and problem solving sometimes through the concept of "playful learning" (Wilson, 2002).

Most multi-sensory approaches take shape in dedicated spaces called "Multi-Sensory Environments" (MSE)-rooms equipped with items that provide gentle stimulations of different senses while offering a nonthreatening, relaxing environment. Researches have already developed different solutions by, such as Snoezelen, MEDIATE, MapSense and SensoryPaint. Snoezelen offer a relaxed atmosphere with pleasant surroundings, soothing sounds, captivating aromas, tactile experiences, massage and vibration, vibrosonic sensations, and gentle movement. Interesting light effects and comfortable seating. MEDIATE stimulates children through visual, tactile and aural channels and allows them to express themselves through body movements, but does not support interaction with objects. MapSense is an interactive map that uses a touch-sensitive surface, tangibles, olfactory and gustatory stimuli. Finally, SensoryPaint allows users to paint on a large display using physical objects, gesture-based interactions, and interactive audio. Still, both MapSense and Sensory paint do not support fullbody movement based interaction. In our project we tried to combines and extends the features of existing multisensory digital systems in a unique way, proposing a pervasive inter-connected space where all children are involved in new forms of fullbody, tangible, playful, multisensory, learning experiences.

36.3.1 Setting

The technology that underlie our system integrates visual contents projected on the walls and on the floor; ambient sound, smart physical objects (textured materials, stuffed toys), connected appliances (bubbles makers and fragrance emitters), smart lights (wireless portable lamps and bulbs). These elements, controlled using a tablet and automated by a PC, react to children's manipulation (tangible interaction) and body movements (touchless interaction provided by a Microsoft Kinect) to offer visual, auditory, tactile, and olfactory stimuli in any sequence, combination and intensity.

36.4 Magika Design

Magika concept come from one of the winning projects of a competition financed with funds of 5 per thousand which promotes the development of scientific research with high social impact. The goal was to overcome the limitations of previous multisensory environments and use advanced digital technologies to transform a usual classrooms of two primary school into a multisensory interactive and smart space that allows children and children with disabilities to live a customized and immersive experience and to learn in an engaging and stimulating way. In order to do that we start our research with a Codesign process that allow us to define users' needs and design children experience in the best way.

36.4.1 Codesign

Two workshops were held with teachers at the primary school. The aim was to share knowledge about the educational needs of children with disabilities, the problems related to educational interventions for these subjects, in the school and extrascholastic environment, and about teachers' technology knowledge level to understand how they could manage the room.

Before the first workshop in order to discuss about the previous points, a google form was sent to all users of the project. The most important results were the following:

- the activities be carried out mainly in a group of 4-5 children, in some cases there will be single subjects;
- group management during the session is both necessary and limiting;
- the devices to "program" the activities of the room are PC and tablet;
- the time of the activity will be 1 hour total, which includes movements from classroom to the room, the actual playing time will be 30 minutes.

After having reviewed the previous points with them, the purpose of the workshop was to understand what teachers expect from the room and what is the ordinary process for children with disabilities enter in the school. In order to do that we used the User Journey Map tool that allowed us to visualize at a glance a series of processes that would otherwise have to be analyzed in their single parts. We outlined with them the main phases starting from the first entry to school, then entering into the specific expectation regarding activities that will take place in the room and what will happen at the end of every activity.

In anticipation of the second workshop we asked teachers their perception of the individual stimuli and objects in the room, so through a second google form based on the "Mapping The IoT Deck" (Vitali and Arquilla, 2018). Tool they gave us useful information to set up our work.

The toolkit is composed by up of 70 cards that summarize the key aspects of smart products. The horizontal side of the card introduces a topic with one main question, while the vertical side deepens it with specific "what if" questions. The Deck provides a framework that may be used freely or for structured activities

During the wokshop we did a demo to make them understand the individual activities and to discuss the results obtained by the survey. Teachers helped us to understand what they could be useful at the educational level.

36.4.2 Users' Needs

Once defined different users' needs we constructed the archetypes. Archetypes reflect the character, the necessity, personality and daily routine of different users. We outline our main users: Caregivers and Children. The greater the understanding of context where the child is inserted the more teachers and therapist are motivated. Total delegation of the results, instead, it causes pressure on the caregiver, who are therefore less motivated action. If the context in which the teacher work is not understood, their motivation decreases.

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Children are the main protagonist of the multisensory room experience and in general their motivation is always high, however could happen that decrease over time. It is important to take in count their need in terms of engagement and accessibility, and to design an experience that keeps their interest alive.

36.5 Experience Development

It was necessary to think about a way to make the transition between every activity more fluid and engaging for children. From this assumption we thought that storytelling could help us to have a coherence during children experience in the room.

Starting from the concept that narrative is a visualization of related events, real or fictional, presented in a sequence of written or spoken words, or still or moving images, we design a StoryWorld (Pinardi and De Angelis, 2006) that underlie the activities to connect them in a natural way and to involve children during their experience in the room.

Before accessing the room, children are told the fabula: Magika was a colorful and harmonic planet. The inhabitants belong to 5 species (hereinafter Senzies, as in, referred to the 5 main senses): Gus (tasters), Olfo (smellers), Auri (hearers), Tati (touchers) and Vis (viewers) living in 5 different continents (lands). One day, the awkward Kaos caused a "BigBoom" and made Magika decomposing into millions of colored balls, scattered throughout the universe. Emi ("the sixth sense", emotion), the wise sage of Magika, decided then to send magical spheres around the universe to be helped in the reconstruction of Magika. Everytime a child will experience an activity in the room, she will collect a ball that, after being grouped with other children's experiences, will be sent to the Magika World.

In order to let children feel part of Magika in small time we developed a preliminary phase called "Avateering" in which they create their own avatar through a dedicated interface. They can choose different features as hair, eyes, mouth and labeled t-shirt). This phase ends by giving children a personal Magika badge. Children's avatar and badge will accompany children across all Magika's experiences (Fig. 36.1). With the intent of understanding children's sensory preferences and dislikes and personalize their experience we thought about an Onboarding phase that allow the system adapts it self to each child's needs by proposing perfectly tailored stimuli.

Fig. 36.1 - Magika Storyworld

36.5.1 Control Interface

In the literature of Multisensory Environments the configurability of the activities and the management of what children do whitin them is a topic that is not so considered and only few case studies can be taken into account. Given the complexity of the system and the variety of activities that the room can offer, it was fundamental to study a solution that allows teachers and therapists to use and control the room in an intuitive way through a simple and usable interface. We thought the Magika Control Interface (MCI) divided into three main sections: CREATE(A), PLAY(B) and LIVE(C). CREATE allows teachers to set new activities and experiences (set of activities) before accessing the room. PLAY, only used inside the room, lets teachers selecting activities and experiences according to what they configured before. LIVE, to control and visualize the flow of the activity in real time (Fig. 36.2).

Once defined the architecture information we started the design of the interface from wireframes, which allow to define the hierarchy of information and make it much easier decisions concerning the layout. We reviewed them with teachers and we reiterated until we found an efficient solution.

After having defined the design system of the interface in all of its component (Typography, icons, palette..), we start to developed the UI following the guidelines of the Material Design, whose main components were identified as intuitive and easy to read.

Fig. 36.2 - MCI

36.6 Usability Test

We did a preliminary usability study with ten teachers with the aim of identify potential design concerns to be addressed in order to improve the efficiency, productivity, and enduser satisfaction.

The test provided 30 printed task to complete and it last 30 minutes (Fig. 36.3). Participants took part in the usability test at the primary school and a tablet with the web interface and supporting software was used in the multisensory room.

A video camera was set. The roles involved in a usability test were as follows:

- Trainer: provide training overview prior to usability testing;
- Facilitator: provide training overview prior to usability testing; defines usability and purpose of usability testing to participants; assists in conduct of participant and observer debriefing sessions; responds to participant's requests for assistance;
- Data Logger: data gathering control;
- Test Observers: silent observer; assists the data logger in identifying problems, concerns, coding bugs, and procedural errors, serve as note takers.

After the test the participants are asked to compile SUS (System Usability Scale) questionnaire composed of 10 questions, concerning usability, which he must fill in independently.

The SUS (Brooke, 2013) questionnaire is useful to understand the results and analyze if the proposed concept has a good usability level. Through a specific calculation the result is a number that it goes from 5 to 100.

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- If the result is greater than 80.3 means that the participants loved the concept.
- If it is greater than 68 means that the concept has been well appreciated but could be improved.
- If it is less than 51 means usability it is substantially low and should be improved seriously.

This was followed by some brief question on the general trend of testing and conclusions that measured their likeability and collected their helpful comments.

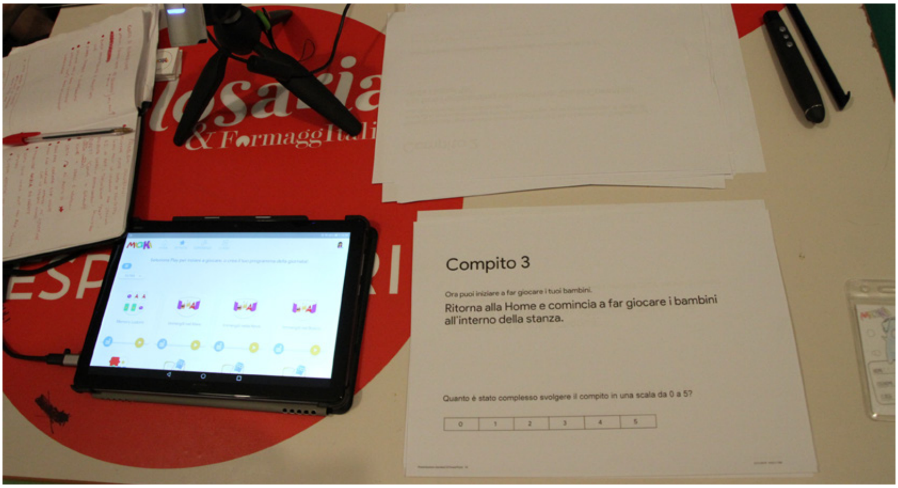

Fig. 36.3 - Usability set

36.7 Results and Conclusion

In the SUS questionnaire answers no result is inferior of 60 and this confirms that the concept was appreciated by all of them. In six cases over 10 the result is even higher at 80.3, while only one case is lower than 68: this achievement makes us particularly proud of the work so far, in fact this was the first time they was ask to manage a multimodal system and the evaluation was made before teachers training.The notes collected during the test suggest both multiple changes to do in order to improve the project, both the merits thanks to the appreciations made by the participants.

We are currently conducting the first experimentation with children and we notice a very good degree of engagement, soon we will analysed the data collected to improve our work on these.

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37. Conversational Agents Teach Humans How to Manage Psychological Disorder

by Priscilla Lanotte, Venanzio Arquilla

Abstract

Over the last few years, it has been possible to look at an interesting technological trend, which stands out among the others, and it is known with the name of "conversational agent". The term includes all the invisible agents able to simulate a nearly realistic conversation between human and machine.

Thanks to the fast growth of technological capabilities, we are aware of the strong relationship which ties man and machine, to the extent that the former can teach many tasks to the latter. What if machines, after being well trained, become able to teach to humans?

This perspective shift is the core of this paper, where we are going to deal with conversational agents used as a supplier of mental support.

Here we aim to provide you with a literature review, which demonstrates the efficiency of the usage of conversational agents for granting mental support through a conversation-based therapy.

The literature review helps to give a reflection starting point. With this, we mean that thanks to conversational agents, and more in general Voice-User-Interfaces, it is possible to teach users how to manage and gradually decrease their mental disease. In this case, humans are going to learn from technology through a new learning perspective which aims to promote mental well-being.

We intend to present the development of a product-service-system in the academic field able to supply mental support. This would be done by teaching to him or her how to behave in an anxious moment.

Keywords: *Conversational design, Psychotherapy, Product-system Design, Learning experience.*

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37.1 Introduction

Since childhood, we have become accustomed to defining the learning experience as the traditional school path that brought us from primary school to the university. We often think that learning is purely something related to the presence of a professor in front of many students.

Fortunately, the learning experience is not simply what we have described above, but is a complex phenomenon, composed of infinite possibilities.

The meaning of experiential learning is related to learning from experience and life. This simple description demonstrates how far is the real meaning of the learning experience is from its traditional concept, based on frontal lectures and classes (Kolb, 2014).

More in detail, the learning experience is referred to as any interaction, which could be a traditional lesson, an online course or a special program where learning takes place. It doesn't depend on any particular location and could involve any person. In essence, the learning experience is the opportunity to learn something new, thanks to many types of interaction.

37.2 Background

In this paper, we are going to focus our attention on a particular kind of learning experience, which involves the presence of highperformance technological products, such as conversational objects. These are digital or physical products with an embedded conversational agent. In detail, they are software programs which can respond to users in natural language, by mimicking a real conversation (Miner, 2016).

Using a conversational object in the learning process means that users are engaged proactively in conversation provided by voice, text or both of them. The conversation delivered by a conversational product could be delivered in two ways: through voice or via text.

The technology behind both kinds of dialogue is very similar. It is a part of Artificial Intelligence. This uses the Natural-Language-Understanding to process the conversational information given through the input and formulates an answer as output (Cohen, Giangola and Balogh, 2004). Both of them look after different aspects, such as prompt definition, grammatical rules and the dialogue logic (Pearl, 2016).

The panorama of conversational agents is growing rapidly thanks to all the technological giants (Amazon, Apple, Google, Microsoft, Facebook, Samsung,

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etc.) which have created hundreds of apps, products, services or devices ready to compete in the new market by using the potential of a conversation between human and machines (Verto Analytics, 2017). This field has opened the mind of many creators and developers in currently operating. The Hype Cycle of Emerging Technologies, developed by Gartner in 2018, illustrates that conversational AI platforms should meet high expectations over the next 5-10 years.

Nowadays, conversational agents in a physical or a digital product, are used mainly to answer general questions or to start a call with someone.

The Fig. 37.1, developed by VoiceBot in November 2018, represents the main tasks that conversational agents are asked to complete. The list contains various typologies of requests, but they are not that different from one another (VoiceBot.ai, Report, 2018).

During this research, we asked ourselves if these were the only ways to interact with conversational agents, and we were convinced that this technology could perform even better tasks than simply playing music, asking for the weather and checking the news.

For this and other reasons, we started to look further into the market to find some other uses for this humanized technology.

After collecting more than 100 case studies and classifying them according to several categories, we noticed that we had even created a teaching conversational agents section, which is going to be explored in the following chapter.

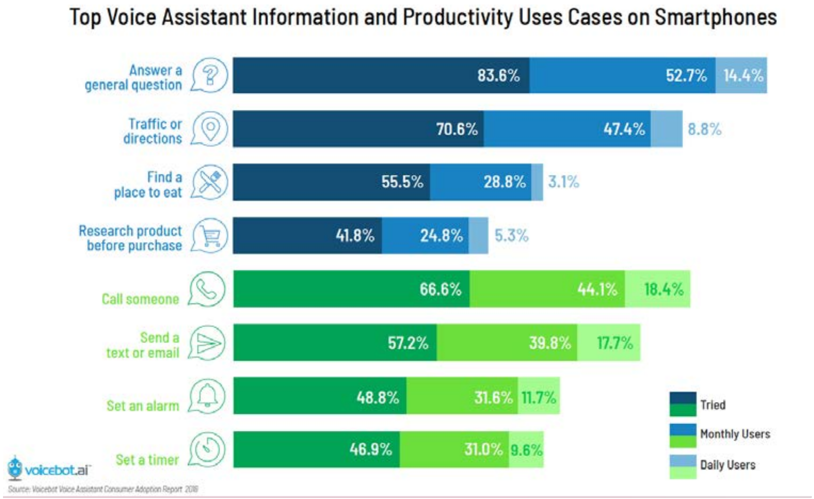

Fig. 37.1 - Voicebot Voice Assistant Consumer Adoption Report 2018

37.3 Method: Conversational Agent in the Learning Process

Among the infinite purposes of conversational objects, we will focus on those who can teach humans a specific skill. We are going to describe better how this technology is influencing the learning experience. This paragraph aims to illustrate a few case studies related to the learning experience process previously described.

First of all, it is necessary to underline that the case studies described here are just a tiny part of all the products which exist on the market. We picked and chose them for three main reasons. On the one hand, we wanted to show that the subjects taught are very different. And this is relevant to make the reader aware of the numerous tasks that conversational objects can perform. On the other hand, we are proposing a variety of supports, in terms of physical and digital objects, because we believe that conversational agents can exist inside several typologies of objects, from the traditional to the most advanced. A third point that we want to illustrate by proposing the following case studies is the variety of audiences that a conversational agent can talk with. This technology can be shaped according to the user targets.

Here is a description of three case studies which have different subject to teach, different support and different audience.

Lily is a smart speaker who can teach Chinese. Learning languages is a tedious process for everyone. For this reason, Lily offers an immersive learning method which is not composed of traditional exercises and textbooks. It tries to teach Chinese by building a real conversation with the user. Again it is essential to underline that Lily won't substitute the presence of a Chinese teacher, but it will help all the people that want to practice anywhere and anytime, without focusing on books for long hours. In this case, the support has been designed to give a shape to the agent, and the Chinese learning experience can be applied to several kinds of users.

37.3.1 Conversational Agent Teaches How to Relieve Anxiety

After having presented the previous case studies, this chapter wishes to focus its attention on a particular series of conversational agents in the learning experience. Here we are going to illustrate a case study which belongs to a specific field of the learning experience, explicitly dedicated to how to manage and relieve an anxiety disorder.

This particular learning method for the users, teaching from a machine, and how to manage anxiety disorder, is our main field of study.

First of all, it is essential to underline that we have previously done a literature review in this field of research, investigating the potential conversational agents as psychological support in the management of a mental disorder. This kind of review was fundamental to design a reliable product service system (described later) which uses the technology of a conversational agent to support people with anxiety.

The literature review was developed over a period of four months in 2018, where we collected 22 studies from books, journal articles, thesis and conference proceedings, on the use of conversational agents in psychotherapy.

The results we obtained were excellent and, in the majority of the cases, it was demonstrated that conversational agents were able to reduce the anxiety level in users. This happened for a number of reasons, such as the creation of empathy, but specifically because the agent was built to provide points of reflection and tips to manage anxiety.

One of the challenges of using conversational platforms for psychological treatments is that the user must be actively engaged. It is very easy to become bored in the early stages of use. The solution is to try to engage the users by giving them tips and suggestions, offering pieces of advice and asking questions as a point of reflection, so that they can reflect on the topic provided in a meaningful way, which could help relieve their mental status.

Below we present one case study of a conversational agent.

Woebot is a chatbot which helps users improve their mood.

It was relevant in the research of Fitzpatrick, Darcy and Vierhile (2017). The study proposes a test on university students with anxiety and depression by using the famous chatbot application Woebot. The purpose was to determine the efficacy of an autonomous conversational agent in helping a total of 70 students for two weeks. Thanks to this study, they were able to demonstrate that Woebot in extremely helpful because there were significant decreases in the level of anxiety.

37.3.2 Product Service System

Easy is a product-service-system which proposes a concrete aid in managing anxiety disorder. Anxiety and depression are a widespread phenomenon in Italy. Over 2.8 million people have this mental disease (Istat, 2018). Before starting with the description of the whole system, we would like to make clear that Easy is still a concept and the design level is in the prototyping phase. Clarifying this aspect is extremely important for us to ensure that nobody misunderstands the fact that Easy is a working progress project.

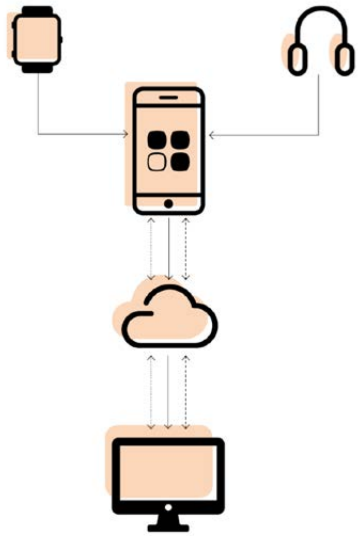

Fig. 37.2 - Interactions Map

Easy is a complex system composed of many elements which see as main stakeholders psychotherapists and patients.

The scheme (Fig. 37.2) illustrates the overall product-service-system in its complexity. To make it more understandable, we are going to explain all of the components and their interaction between the users and among all the elements.

Easy Computer Dashboard is a computer dashboard designed for the psychotherapist involved in the therapy with the anxiety sufferer. This allows the psychotherapist to manage appointments with all the patients through an interactive agenda. The innovative feature of the dashboard is the ability to create interactive pages for the patient's clinical records.

In this particular page of the dashboard, the psychotherapist can gather all the notes taken during the weekly meeting with the patients, all the receipts are given to the patients and can suggest meditative exercises. Patients can receive these suggestions by using Easy Mobile Application, described later.

Thanks to the connections with Easy Mobile Application, this dashboard shows all the exercises that the patient has completed. As a consequence, the psychotherapist can take control of all the improvements and all the completed meditative practices through the graph shown in Fig. 37.2.

If Easy Computer Dashboard is the only element of the system dedicated to the psychotherapist, Easy Mobile Application, Easy Smart Bracelet and Easy Smart Headphones are the three components designed for patients.

They are users with elevated levels of daily stress and anxiety who need to learn how to manage these situations using special exercises similar to meditations. To monitor anxiety, the system even provides some devices to track the physiological changes based on the stress level.

Through the connection with the mobile application, the smartbracelet and a pair of innovative headphones, the patients will receive help immediately when the anxiety attack is in its most severe phase. Below all the elements are described starting from Easy Smart Bracelet.

Easy Smart Bracelet, is a wearable device, without any screen, with the task of tracking three fundamental physiological parameters: temperature, heart bit and galvanic skin response. The device can communicate with Easy Mobile Application when it notices a high level of stress to quickly provide a meditation exercise to reduce the stress level.

The other wearable device active in Easy system, is Easy Smart Head-phones. These are special headphones with three EEG sensors able to capture the level of concentration of the user during the meditation.

The last component of the product-service-system is Easy Mobile Application, which is a mobile application that manages the data received from the wearables tools and proposes a series of meditation exercises.

By using this application, the patient will be asked to perform the mediation suggested by the psychotherapist, to choose whichever exercise he or she prefers and to meditate anywhere when Easy Smart Bracelet detects a moment of anxiety.

Every time the patient meditates the physiological data is transferred to the psychotherapist dashboard.

The innovative characteristic of the meditations is the possibility of talking with a conversational agent to build a real conversation between the parties.

Thus the user is guided in the reduction of stress levels.

After having described all the elements of the product-service system, this chapter aims to illustrate and explain the first tests developed to understand the strengths and weaknesses of the whole system.

The primary purpose of the test was the improvement of the usability of Easy system, analyzing user behaviours, the reactions and the interactions, to understand what was necessary to improve it.

The proposed test is intended to evaluate the entire proposal of the concept used by real users. Specifically, two types of tests have been performed.

1. One aimed at patients who were asked to evaluate the flow of Easy Mobile Application and the interaction with Easy Smart Bracelet and Easy Smart Headphones. The conversational agent present inside the mobile application was simulated with Woz testing (Pearl, 2016). Moreover, both wearable devices were created quickly with a low fidelity prototype.
2. The other aimed at psychotherapists, who were asked to evaluate the usability of Easy Computer Dashboard.

Each test consisted of several Tasks, which the participants were asked to perform using the wireframing prototype. Besides, participants were asked to answer some questions related to the tasks previously performed, adopting a simplified SUS (System Usability Scale) questionnaire (Brooke, 2013).

The participants were selected based on their similarity to the target of users. In fact, for a total of 9 participants, there were five anxiety sufferers and four psychotherapists.

The entire process of the test lasted one hour per participant, and it was divided into three main parts. The first one consisted of the introduction, a small interview to collect personal data, and the explanation of the test.

The second part consisted of the core of the test with the completion of 7 main tasks and some further questions. The final part consisted of a questionnaire and conclusions.

After completing all the tests on nine participants, we analyzed and compared the data obtained to have a clear vision of how to act further.

37.4 Results

Apart from the many changes made to the product-service system, we were delighted with the results.

Through a specific calculation, a result is a number that it goes from 5 to 100.

In general, for the SUS test, if the result is more significant than 80.3 means that the participants loved the concept. If it is greater than 68 means that the concept has been well appreciated but could be improved. If it is less than 51 means usability, it is substantially low and should be improved seriously.

We discovered that in eight cases of nine, the results was higher the 80.3. They appreciated the system and were happy to use it during the test.

We adopted a qualitative approach with a reduced number of participants, following also the Nielsen (2013) prescription that states that "*Testing with five people lets you find almost as many usability problems as you'd find using many more test participants*".

Otherwise, at the end of the tests, it was easy to note that participants, especially the anxious ones, were engaged during the meditation with the simulated conversational agent.

The following paragraph will show the main findings of our research on the power of a conversational agent in the learning experience for anxiety relief.

37.5 Conclusions

Conversational objects are increasingly becoming part of our daily life. They help users to solve simple tasks.

This technology-based on Natural-Language-Understanding is continuously improving its performance, and the number of tasks which it can solve is growing.

Nowadays, thanks to the level of accuracy, conversational agents are helping people with mental diseases, as we saw in Woebot (Fitzpatrick, Darcy and Vierhile, 2017).

The main findings are listed below.

First of all, we noticed that the separation between physical and digital products no longer exists.

By this, we mean that it is now possible to observe good integrity of physical and digital components, within a single service.

The mix of these two types of solutions is called Phygital (Zurlo *et al.*, 2018).

A predominantly digital service that relies on products to achieve maximum performance is therefore easy.

Moreover, user testing turns out to be essential for the whole design process. It represents a step in conveying value and the opportunity to come up with a meaningful purpose. The User-Centred Design sees the user as the focal point where the design takes place. Therefore, testing every aspect of the final design is fundamental. Shaping the final product according to the user needs, is what provides relevance to the project. This is a rule valid not only in conversational design but also within all the fields of design.

An additional challenge of using conversational platforms for psychological treatments is that the user must be engaged actively. This means that it is extremely easy to become bored in the early stages of the use if the patient is not involved dynamically. The solution is to try to engage the users by giving them tips and suggestions, offering pieces of advice and asking questions as a point of reflection, so that they can reflect on the topic provided in a meaningful way, which could help them in relieving their mental status. This will create an efficient learning experience to decrease stress levels. Furthermore, driving the conversation along a specific path makes the users feel that they are engaged in a real conversation, and this helps them establish empathy with the platform.

The development of Easy is still running, and we are working on it, to propose a feasible and efficient product. Many other milestones are planned in the near future.

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Designing for Inclusive Learning Experience

Conference – Florence, 10 May 2019

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The book presents contributions submitted at the Conference "Designing for Inclusive Learning Experience", which was held in Florence on May 10, 2019, at the Department of Architecture DIDA of the University of Florence.

The conference main topics regard the application of Ergonomics and Human Factors to Education, Gamification and Inclusion.

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FrancoAngeli
La passione per le conoscenze