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Chapter 1

DESIGN FOR SOCIAL INNOVATION: WHAT ROLES FOR DESIGNERS?[1]

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1. INTRODUCTION

This chapter takes a conceptual approach about the roles of designers and their inclusion in social innovation. A conceptual review is made from selected literature with the aim of answering the question: What roles should designers take in social innovation? To give an answer to this question the article first presents a review of the concept of social innovation. Then an argumentation about design methods and finally a summary of tensions and dimensions for designers to consider before entering the field of social innovation. In the concluding, focus is given to the tension between being a designer that is a peer in a community and being a designer that is an expert. The main contribution of this chapter is to designers or researcher wanting a framework or heuristic to position their work.

In recent years, the scope of Design has been broadened. The capacities to solve problems by design are now used to deal with problems that are immaterial—such as in the norm-critical design (see Isaksson, 2017). In essence, this means a relocation of the purpose of design from the object to the effects and relations supported by the object—from aesthetics to ethics in the model of Findeli & Bousbaci (2005). This change in the locus implies that most of the classical

1 The content in this chapter is a revised version sourced from the Master Thesis presented by the author at Anadolu University, in Eskisehir, Turkey in 2017.

design methods—focusing solely on technical aspects of production—must be complemented.

Unlike technical problems, social problems are usually ill-defined and cannot be solved by a one-solution approach. These problems—that may come as new to professional designers—are not new. Rittel & Webber (1973) called them wicked problems. The contribution of design to these wicked problems is however different from the contribution of planners. Designers work on materiality, which means that to bring design to wicked problems, designers must acknowledge how the material world produces and reproduce these problems—see ontological designing (Willis, 2006). Moreover, if designers want to be recognized as mediators of positive social impact.

Notions of the social impacts of design are not new. Lawson (2006, p.29) stated: *"the future role of designers are inevitably linked to the kind of direction in which we wish society to go*". This is an acknowledgment of the intertwining of the context—current and expected societies—and the work of making the world—conditioning and intervening through design—. Design is one of the many driving forces for the future of societies, it encompasses a contribution to not just understanding, but to make—in prescriptive or normative modes.

The social solutions sought though design should not be reduced to the mere modification of the materiality in which people's life is embedded. These solutions should consider the immaterial dimensions of existence—what is understood, valued, and thought. Margolin & Margolin (2002) already made a call for a social design based on methods not found in classical design practices, hoping that a reorientation would allow designers to obtain the necessary skills and tools to work on the social.

A first question emerges here, what is social? This is a question that escapes the scope of this chapter. Although it can be said that the social is the concern of social scientists, social transformation is a human process that requires the dedicated efforts of multiple forms of knowledge. For designers, it is also a call to acknowledge the work of other professions that have long traditions working on improving the conditions of human life. Regardless, designers integrate many concepts from social sciences, especially those that facilitate the understanding of how humans think and how they relate. Irremediably, design professionals are permeated by social science, but not by social inquiry. In practice, it appears to be that the locus

of the social is different in design. "Social" is linked to doing good and improving the situation of people's everyday life.

One stream of thought in current design discourses derives from what Papanek (1985) and others called integrated design—during the 1970s. In integrated design, it is assumed that there are social and environmental implications in each designed object—because of mass production and its extensive effects. The point of Papanek (1985) was to set a code of conduct or ethics, in a certain moralizing way—recent similar calls include Monteiro (2019).

The idea that designers are capable of producing good is also found in the—now almost cliché— definition of design by Simon (1996, p.111): *"Everyone designs who devises courses of action aimed at changing existing situation to preferred ones".* This definition is echoed by Manzini (2015) when defining design for social innovation (hereafter, SI). The conceptualization of SI as the transformation of relations and not in the morality of the work of a designer. Manzini (2015) makes a distinction between moral—charitable—work for good and work that is simply engaged in the actual needs of the many stakeholders it serves.

SI is a space—sector or arena— that offers opportunities for the broadening roles of design. These roles are not strictly connected to manufacture and commercial logic. Tharp & Tharp (2019) describe an emerging framework of design practices that are not base on the commercial agenda and try to create a proposition for how to deal with them. This framing (Tharp & Tharp, 2019) acknowledges a plurality of design objectives and methods. To apply such a method for SI, it is necessary to understand the implications it has as a concept and a space of action.

Here, SI is understood as transforming or changing relations, the main question of this chapter is raised as: What roles should designers take in SI? These roles are found under different banners, such as social impact, social change, and social transformation. The following three sections in this chapter discuss some of these possible roles. Section 2 presents a review of SI, followed by section 3 which talks about the method or process implication for design. Section four deepens the roles for designers, followed by a brief conclusion.

2. WHAT IS SOCIAL INNOVATION?

First, a brief review of SI as a concept. Rana et al (2014) present an introduc-

tion to the concept by commenting on an origin in the 1970s. This origin was connected to the work of social science scholars in francophone countries. At that time, it was considered for any activity that engaged with contemporary social problems to accomplish beneficial outcomes for the majority. Later the term was adopted by management and business sciences scholars and introduced as one of the dimensions of innovative business strategies during the 1990s. In the last decade, it has become more of the interest of policymakers in the public sector, as it involves social changes. According to Rana et al (2014) most studies about this concept are conceptual work, lacking applied examples.

In the study of Unceta et al (2016), SI is considered a polysemic quasi-concept. There are multiple takes about the term; usually with corresponding models of how the impact is measured. The missing consensus on the definition of SI results in indicators and measurements that do not always correspond to the goals. This situation results in almost any effort being considered a SI. In the work of Unceta et al (2016), an index to measure impact is reported as a tool, based on social impact instead of on financial revenues. This case highlights an important factor of what can be considered the outcome in this field, which, unlike in industry, it is not revenue, nor products, it is social impact in the form of social change.

In Pol & Ville (2009), some meanings given to the concept are characterized and put in relation as constructs. It is not a formal typology, but provides categories of study: 1) about institutional change, 2) about social purposes: as quality and quantity of life, 3) about the public good: questioning what public good is, 4) as needs unattended by markets: stressing the importance of separating it from business innovation.

Mumford & Moertl (2003) present two valuable aspects of SI. The concept is seen as a process of creation—which is the area of specialization of design— and a set of outcomes for the formation of renovated social forms—institutions, industries, policies, forms of social interactions—. The creation of new social forms can be taken as the first paradigm of SI; complemented by a second one that focuses the concept on the improvements of quality and quantity of life.

The work of Hämäläinen & Heiskala (2007) can be included in the first paradigm—the creation of new social forms—. In this paradigm, SIs are considered as new mental paradigms; that emerge as a response to the effects of technologies and policy changes that affect the techno-socio-economic space of society. These responses generate new social issues and contestations to the established social

structures and institutions. Thus, generating opportunities for creativity and innovation aimed at the formation of new institutions. Consequently, creating new conditions in the social context and giving opportunities to creative modes. Social changes might come from the new connections that originate from the expansion of new technologies. Particularly communication technologies would drive new social forms; stressing challenges on the normative and cultural rules through which societies organize. These changes would result in new societies as these are actualization (reification) of cultures (Hämäläinen & Heiskala, p.63-64).

The second paradigm for SI can be found in the works of Geoff Mulgan (2007) and the Young Foundation (Murray et al, 2010). These are good sources about how the field of SI is being conceptualized and molded for and from the perspectives of business sciences, emphasizing SI as an economic force. Mulgan (2007) presents SI as a process with stages that could emerge from different societal actors. The general process has three stages: one of generation or gathering of ideas; one of put into practice and reformulation; and one of appropriation, growth (scale), or inclusion by established social structures.

Manzini (2015) refers to SI within the second paradigm and he describes the importance of SI to design as a sector that is growing in its importance for governments. SI is an opportunity to enact solutions for problems that in the past were considered intractable. Design is a means that enables tangible signs of the problems. One of the problems as mentioned by Antadze & Westley (2012) is that outcomes are usually measured in terms of generation of economic value—revenue streams— instead of in the multidimensional factors affected—inclusion, mindsets, resources, among others—.

In summary, here the assumptions are: 1) there is no consensus on one specific definition of SI. 2) at least two paradigms are found. The first one focused on the creation of new social forms—mediating relations— and the second one focusing on attending social goals through the creation of specific economic actions. The first paradigm is the result of dissatisfaction with how social relations are carried—between groups of people and individuals. Any kind of relations between groups and individuals, that is founded on interactions that are institutionalized —meaning a way of doing that became a custom— can be subjected to be changed by SI. The second paradigm sets SI as the intentional activity towards a major change in recognized social problems—e.g. bringing water to isolated rural areas—, through concrete actions—e.g. setting a distribution of water through a

tax paid by people in urban places—. This latter paradigm can appear easier as the project orientation has a concrete goal, but the long-term effects may be as difficult to measure as in the first paradigm.

3. DESIGN METHODS: DEALING WITH SI

The options to approach SI are multiple. Ranging from Design Thinking for non-designers to action research for data gathering —using social sciences and anthropology techniques—. Furthermore, these are strengthened with concepts such as co-creation, collaborative design, transformative design, communities of practice, participatory design. Bayraktoğlu et al (2014) mention three groups of practices of design in the industrialized countries of the World (Europe and USA); based on the country and contexts from which they emerge. From England, developed by the British Council of Design and the financial sectors: service design, transformative design, and design for financial services. Coming from the work of Politecnico Di Milano and DESIS Network, in Italy: creative communities for sustainable lifestyles and research for sustainable design. And finally, from the USA: design thinking and design for development. Each of the models of design refers to a different idea of what designers must do.

Some other models, that also connect design with the social space, don't intend to elaborate feasible outcomes. Rather, used to question how things are done, as it happens in the cases of critical and speculative design, which are supported on answering what can be instead of what ought to be (Auger, 2013).

Most of the models share the characteristic of being based on Designing in close contact with the people that are intended to be served. It includes making them part of the processes. In some of the models, the designer is only the facilitator, mediator, or guide. The designer is seen as in charge of opening spaces for social actors to come up with solutions to their problems. In general lines, the work of designers is less related to the creation of products, and more to the management of a collective process of creation. These processes are supported by the ideas and interactions between multiple actors within a social context (community).

Sanders & Stappers (2008) also identified two paradigms in design practices about social issues: 1) one based on the user as a subject of study; 2) one that takes the user as a partner. The identification of these two paradigms implies that

designers working with social issues need to confront the ethical dilemmas of acknowledging the people they intend to design with—or for—.

Manzini (2015) describes two roles that designers can assume when approaching SI: 1) designers designing with the community as peers to the other members, and, 2) designers designing for the community as external agents, conceptualizing and developing specific solutions. Concepts such as participatory design or collaborative design (co-design), provide a framework for designers to act (Manzini, 2016). Community efforts, although not always driven by design, may also result in SIs (Manzini, 2015). From the perspective of Manzini (2015), to drive changes towards better social states, Design should be reframed too, as a community endeavor.

Designers—or any other individual member— cannot be expected to leverage the well-being of a community. Participation of all the actors involved in the context of a community is preferable. Participation "is based on the principle that the environment works better if citizens are active and involved in its creation and management instead of being treated as passive consumers." (Sanoff, 2014). By using participatory approaches, designers should assume that solutions have to be more than just physical products emerging from their (individual) geniuses.

Collaborative design (co-design) is a complementary concept to the one of participatory design (although sometimes used interchangeably as in the case study of Aitken & Shackleton, 2014). It invites designers to engage with communities —in terms of publics— by establishing relations beyond one-time product solutions (Botero & Hyysalo, 2012). Empowering people to take on the issues affecting their immediate realities is part of what design can propel as a force for change.

Manzini (2015) indicates that SI can be promoted from two different levels: 1) from top-down when the process is pushed forward by institutions, authorities, and organizations that are not the community affected by a social issue; and 2) bottom-up efforts, when members of the community affected, get organized, engage in activities and embody the solutions needed. In either case, the participation of designers is a requisite for SI. Designers who integrate with communities could serve better in transmitting design values and culture into socially innovative solutions.

Julier (2017) notes that new approaches —user-centered— tend to have specific visual forms: post-its, boards, Play-Doh, Sharpies; which are signs of a shift

of value in Design, from objects to processes. A process that is enacted through a series of design artifacts *"... concerned, at least in theory, with working with the situated realities of everyday life whether these actually exist or are speculations"* (Julier, 2017, pp.145-146). Consequently, giving more importance to the process of designing and less to the outcomes. There is room to question if these new forms of design are only being put forward by specific institutions, such as higher education institutions, or if practitioners outside the academic space are working with communities.

It can be questioned if the emergence of SI will have an impact on design and provoke a renewal of its methods, or if instead, it will remain an area for which design has an instrumental value, but will not become completely embedded.

4. SOME ROLES TO DESIGNERS

This section presents a summary of concepts that could help designers wanting to work with social innovation. Table 1 at the end of this section presents a summary—and suggestion— of the dimensions that designers could consider before participating in SI. This summary departs from a series of identified tensions as follow:

About the roles of design

1) The kind of problems design addresses. This represents a tension between technically oriented and socially oriented solutions. The tension is set between tangible and intangible outcomes, objects vs. processes. In specific terms, it results in a shift from design as visual and product creation, to design as systemic intervention through tactics and strategies for change.

2) Who can enact design? This concern results from a tension between the designers as experts and design as a human attitude. The connotation of the designer as an expert means that the designer is the owner of the creative process, while the connotation of design as a human attitude means that creative processes can be initiated and conducted by anyone—regardless of their expertise. The proposal of a third space, in which the designers act as mediators could be helpful to reconcile this tension.

About SI

1) Tensions result from understating SI as changes in norms, behaviors, values, worldviews, and institutions that shape social interactions. This way of understanding SI is closer to the perspectives in social sciences and involves the recognition and awareness of other social dimensions, such as power (politics).

2) The second understanding of SI as changes towards the achievement of social goals, which are not covered by already existing markets or public policies. This paradigm is closer to the perspectives in business and economic sciences. SI is considered as both a form of help and an economic sector.

3) The acknowledgment of the origin of the SI. This means the consideration of aspects regarding who enacts and who drives the expected changes. It can be as mentioned in the previous section from the top-down (powerful actors) or the bottom-up (grassroot organizations).

4) The kind of organizations, a tension between pervasive commercial agendas and other forms of social organizations should be identified by designers.

About design and social aspects

1) A tension emerges between design as creating conditions for specific individual behaviors and design as creating opportunities for the well-being of most of the society. The first one assumes that the control is given to designers, while the second one assumes that designers participate in mediating opportunities for most of the societal actors.

2) Another tension is the role of design, with or without ethical concerns. In some cases, the work of designers addresses the individual need of each designer to make an income, this is a practical issue that cannot be overlooked.

3) How social aspects are approached can also result in tension. In it, the discussion goes around the acknowledgment or not of power issues and the imbalances in participation and representation of certain groups that could be affected by the deployment of concrete designed outcomes.

About practices

1) In applying design research to social issues. It can be as a process for everybody: the designer acts by using action research techniques, bringing together members from a community or group. Against research as a process to gain insights: the designer acts as a researcher intending to gain insights from the members of a community, to design for them but without them.

2)There is also tension between the commercial space and the academic space. The reality of design in the commercial space might not be as it is conceptualized in the academic space. The first one is concerned with products—objects and visual outcomes—while the latter is concerned with changing the practices of design.

Table 1. Summary of dimensions to consider when dealing with design for SI

Concept	Dimension	Attributes	
Roles of Design	Orientation:	Technical- commercial.(Profits)	Social (well-being)
	Solution:	Tangible(object)	Intangible(Process)
	Actor:	Everybody (Diffuse)	Designer (expert)
Social Innovation	Goal:	Changes in interactions. (is not tangible, a process)	Solutions to solve a social issue.(can be product or services)
	Origin:	Top-down (institutions)	Bottom-up (communities)
	Funded by:	Other actors (donations,government budget)	Generates a self-sustain. (Own economy)
	Organization:	Alternative types of organizations.	Social Businesses

Design and Social aspects	Vision:	Interactions. (Through products or services)	Responsibility. (Ethical dilemmas)
	Social context:	Acknowledged (specific community characteristics)	Ignored (one-size-fits-all solutions)
	Relations:	Can be changed by design	Not in the scope of Design.
Practices of design	Type:	Non-participatory (conditioned)	Participatory (autonomous, voluntary)
	Outcome:	Non-Collaborative (insights)	Collaborative (co-designed/co-created)
	Solutions:	Systemic, considers the context in depth.	Shallow, one-time solutions.
	Space:	Commercial (Design Thinking)	Alternative: Academic (Design research) Community (diffused design)
	Designer's proximity:	Close (a peer)	Distant (expert)

5. CONCLUSION

The role of the designer can never be monolithic, as designers need to adapt to the contexts where they serve a function. Notwithstanding, an ongoing totalizing and hegemonical process of globalization puts designers at risk of having to conform to a one-fits-all set of roles. However, a distinction can be made between, design as a professional practice and design as a human attitude. This means that the creative capacity of design is beyond the scope of professional designers. An answer to the research question posed in the introduction— What roles should designers take in SI?

— can be found in the roles suggested by Markus in 1972 (Lawson, 2006, pp.29-30): 1) a conservative role of the designer as the dominant actor of design. 2)A search for structural change that would bring the end of professional design. 3)A middle way, a path in which professional designers work in cooperation or in

communication with those they serve

Furthermore, it must be stated that SI is not detached from industry or commercial agendas, and it depends on the understanding taken about what SI entails. If it is understood as changes in institutions, norms, behaviors, or interactions, then the outcome awaited from designers should deal with innovations aimed at impacting those aspects. This means as social change. But, other paradigms of SI can be considered, such as considering it an endeavor to serve communities unattended by the markets and public institutions, by helping them reach a better state of life through cheaper products/services; or by gaining profits from sales, then a business-wise mindset should be expected from designers.

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Chapter 2

INNOVATION PRINCIPLES AND THEIR POSSIBLE APPLICATION IN SOCIAL DES IGN

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1. INTRODUCTION

This chapter examines the concepts of stressor (i.e. challenging conditions given by the environment, resources and knowledge level), antifragility, cumulative experience, context, simplicity, emergent platforms among others, as well as its possible application in product design, intended to solve or mitigate the effect of social problems. The document is divided into five chapters, being the first one devoted to the theoretical review of literature from four knowledge areas: Cultural, Scientific, Experimental and Logistic. In the second chapter, ideas and concepts from the different literature resources and knowledge areas are combined in the so-called Theoretical Triangulation Process, which final aim is to generate statements based on the bibliographic review. The third chapter includes a further development of the statements reached in chapter two and from them, it is proposed a set of principles extracted from the literature review to promote technical innovation in social design. Chapter four includes a comparison between the suggested principles and those already developed in the existing design-related literature, identifying similarities, differences and opportunities so that a richest framework of innovation in social design conducted by institutions or organizations can be created. Finally, the fifth chapter presents the conclusions, challenges and possible opportunities for its application.

2. METHODOLOGY

The methodology follows the master thesis framework suggested by Professor Dr. Antonio da Cruz Rodrigues, director of the masters of Design Management and Product and Space Design at Universidade Europeia in Lisbon, Portugal (Cruz Rodrigues & Cunha, 2017). It follows a Theoretical Triangulation process, which can be understood as "…the use of multiple theories or hypotheses when examining a phenomenon (Denzin, 1970). The intent is to conduct the study with multiple lenses and questions in mind, to lend support to or refute findings. In theoretical triangulation, the perspectives or hypotheses used in the study may be related or have opposing viewpoints, depending on what the researcher hopes to accomplish (Denzin, 1970)" (Thurmond, 2001).

As cited by Thurmond (2001), "having rival hypotheses also challenges researchers to look beyond the obvious explanations. Multiple perspectives can help rule out competing hypotheses, prevent premature acceptance of plausible explanations, and increase confidence in developing concepts or constructs in theory development (Banik, 1993)."

For this work, the main purpose consists of getting unbiased perspectives from a theoretical review, covering a variety of authors and perspectives ranging from idea generation to climate change and its effects on human evolution, topics disconnected with the current theories and methodologies of product design, with the core aim of coming up with different ideas and new problem-solving approaches.

The original methodology (Cruz Rodrigues & Cunha, 2017) is divided into three phases presented below:

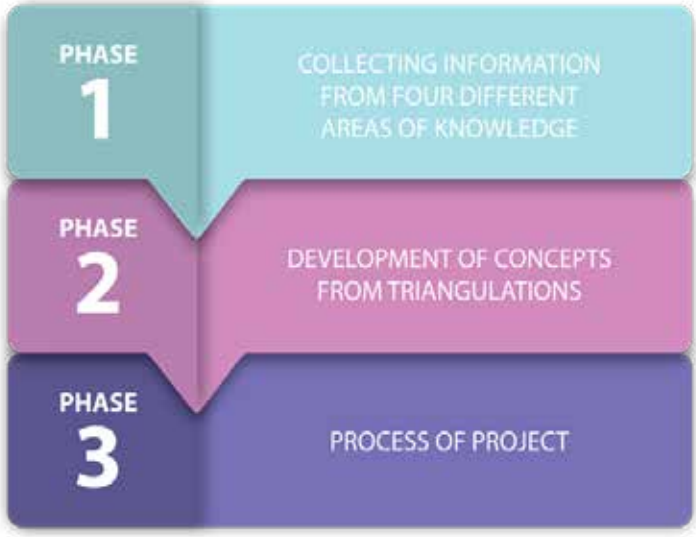

Figure 1. Phases of a thesis project. Source: Cruz Rodrigues & Cunha, 2017.

However, for this work, a fourth phase was included, denoted as Evaluation. In this part, the developed project is theoretically evaluated by contrasting it against current theories of design, in order to identify complementation opportunities for a richest framework. All the four phases are explained in detail below.

3. PHASES 1 AND 2. THEORETICAL EXPLORATION

In these phases, the pertinent bibliographical information available is reviewed and organized. The main objective is to amplify the knowledge, seeking a broader view that allows a free reflection of the current problem.

In the first phase, the theoretical framework is separated into four knowledge areas: Cultural, Scientific, Experimental and Logistic (see Figure 2). For each knowledge area, there were chosen different books judging by their group membership, as well as its relevance regarding solutions for social needs. The reason of selecting books from various areas of knowledge, is to obtain information from different scopes which helps to extend the perspective of mind. Thus, interesting connections between the main topic and others from different realms of study that had never been thought of, can eventually be found.

At the end of each knowledge area, a resume of the main ideas collected in the bibliography is presented, synthesizing information. To conclude this section, general concepts, important for the understanding of the whole project are listed and explained.

1.The **cultural knowledge**, brings us back to common sense. It portrays beliefs, arts, moral, laws, costumes, behaviours and habits of human beings. In this area, the selected books were: Antifragile, Things that gain from disorder (Taleb, 2012) and 'The Social' and Beyond: Introducing Actor-Network Theory (Dolwick, 2009).

2. **Scientific knowledge** explores facts, whose analysis do not depend on the viewer's interpretation. The facts are presented in a systematic way thus that they can be verified, by using processes of observation, research, experimentation and validation. The books reviewed for this area are: The world until yesterday (Diamond, 2012) and The long summer: How Climate Changed Civilization (Fagan, 2005).

3. **Experimental knowledge**, involves all that knowledge resulting from observation processes, analysis and experimentation having as object of interest the nature, societies and man. This area differs from the scientific knowledge in the fact that it might not replicated but stills is the result of a specific experimentation. For this area, the chosen book is What makes us human? (Pasternak, 2007).

4. **Logistic knowledge** includes the procedures and necessary steps to create ideas, knowledge or products. It presents guiding contents for the execution of tasks, practices of procedures and analysis of activities. The main representative of this area is Steven Johnson, with his book Where good ideas come from: the natural history of innovation (2010).

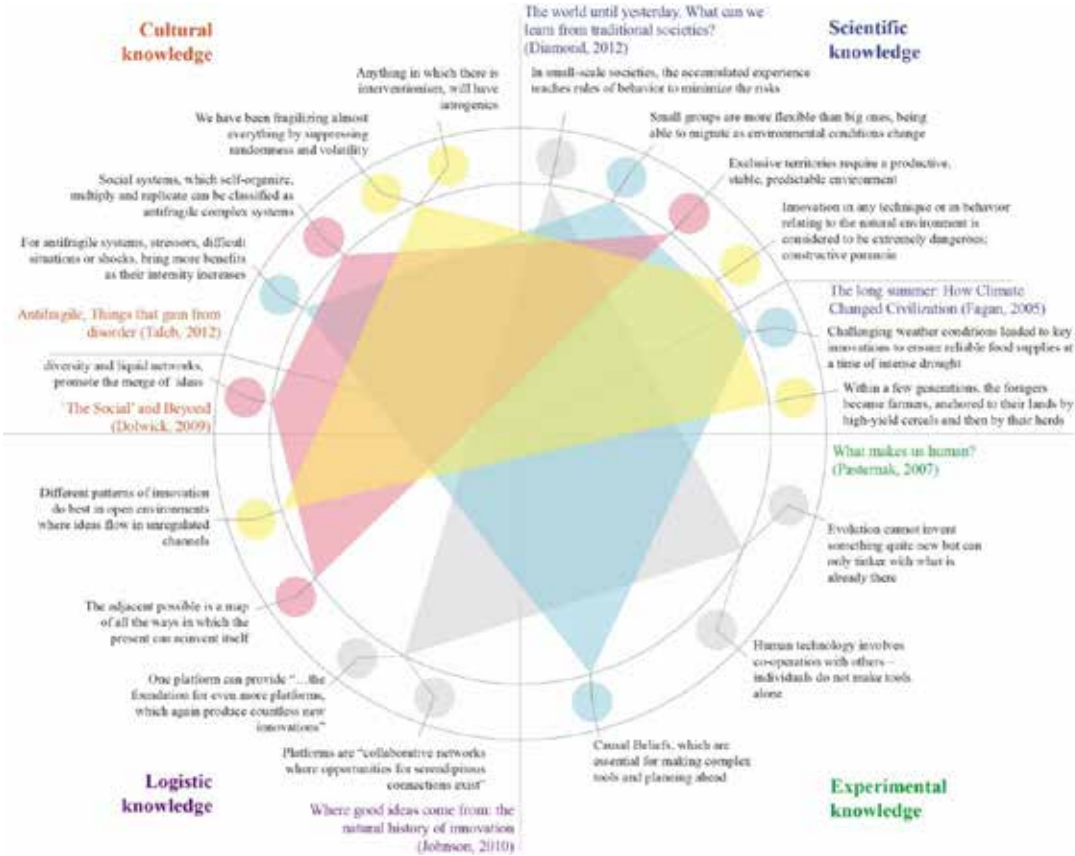

Figure 2. **Theoretical Triangulation process**

4. PHASE 3: SUGGESTIONS FOR A SOCIAL APPROACH ON DESIGN

In the third phase, a set of principles to improve effective innovation in social design is presented. They are the result of a Theoretical Triangulation process in which ideas from authors belonging to different study fields are combined to come up with new ideas. According to Denzin (1970), "In theoretical triangulation, the perspectives or hypotheses used in the study may be related or have opposing viewpoints, depending on what the researcher hopes to accomplish" (Thurmond, 2001).

4.1 Emergent Platforms and Cumulative Experience Provide the Basis for Innovation.

Emergent platforms are cumulative levels of knowledge, experience, tools and all the possible elements previously developed by others, which may facilitate innovation, by giving a basis from which to start. Steven Johnson (Jansen, 2013) recognizes platforms as an element which enhances the effect of "***collaborative networks where opportunities for serendipitous connections exist"*** (Jansen, The key lessons from "Where Good Ideas Come From" by Steven Johnson, 2013). Additionally, the fact that one platform can provide ***"…the foundation for even more platforms, which again produce countless new innovations"*** (Jansen, The key lessons from "Where Good Ideas Come From" by Steven Johnson, 2013) demonstrate its important role in any kind of system. Charles Pasternak reinforces this idea by expressing that "***evolution cannot invent something quite new but can only tinker with what is already there***" (Pasternak, 2007, p. 177) meaning that innovation is in fact the reshaping of cumulative previous experiences.

In the case of ***small-scale societies***, platforms are based on the experience transferred throughout generations. Thus, ***children learn in the course of accompanying their parents and other adults*** (Diamond, 2012, p. 136)**.** The ***accumulated experience teaches rules of behaviour to minimize the risks*** (Diamond, 2012, p. 184), but also, the necessary techniques to create tools and solutions in community as expressed by Pasternak when says that "***Human technology involves co-operation with others – individuals do not make tools alone***" (Pasternak, 2007, p. 177).

Figure 3. Emergent platforms and cumulative experience provide the basis for innovation

Figure 4-5-6. The shoe that grows

In Figure 4, it is shown how emergent platforms, i.e. cumulative levels of knowledge, resources, experience and tools, are essential for innovation. The three scenarios shown above, exemplify how the more experience and platforms exist, the more innovative the solution can be. Scenario 1 is the most basic one, in which an individual has to use his physical capacity to solve the problem. In scenario 2, the person makes use of an existing tool previously developed by others with the same purpose of transporting loads, being able to provide the same solution in less time, i.e. more efficient. Finally, in scenario 3, the person combines two tools, his knowledge about them, and even though one of them (the unicycle) is not intended to transport loads, it is effective to commute faster from one point to another.

This innovative solution means the same job done in less time.

Figure 5 exemplifies the first triangulation. In order to prevent soil-transmitted diseases and parasites that affect poor children who cannot afford changing their shoes at the same rate as their feet grow, and taking into account the experience of locals at designing their traditional shoes, plus the existence of materials which last longer and offer the required comfort, the so-called "shoe that grows" was designed.

According to their creators, it is "a shoe that grows five sizes and lasts for years... It was developed with the help of multiple shoe design firms inspired by feedback from those who need them." (theshoethatgrows.org, 2017).

Other examples worth to mention are the Global Positioning System (GPS), originally developed for military use, it has now spurned countless innovations from GPS trackers to location-based services and advertising, and YouTube which if launched in the 1990s, it would have flopped, since neither the fast internet connections nor the software required to view videos was available then (Jansen, The key lessons from "Where Good Ideas Come From" by Steven Johnson, 2013).

4.2. Innovation and Sophistication Spark from Difficult Situations.

In the evolution of human kind, and still in traditional societies it is shown how small groups are more flexible than big ones, being able to migrate as environmental conditions change (Diamond, 2012, p. 201), but as their numbers increase, they are forced to settle in specific areas, having to adapt and innovate to counteract challenges. This ability can be associated with a unique human characteristic: ***Causal Beliefs, which are essential for making complex tools and planning ahead*** (Pasternak, 2007, p. 180). The evolution of human civilizations, where challenging weather conditions leaded to key innovations in human kind such as plant cultivation and animal domestication to ***ensure reliable food supplies at a time of intense drought*** (Fagan, 2005, p. 102) is a clear example of this forced innovation and sophistication. Human societies can be seen as ***antifragile systems***, for which stressors, difficult situations or ***shocks, bring more benefits as their intensity increases*** (Taleb, 2012, p. 286)**.**

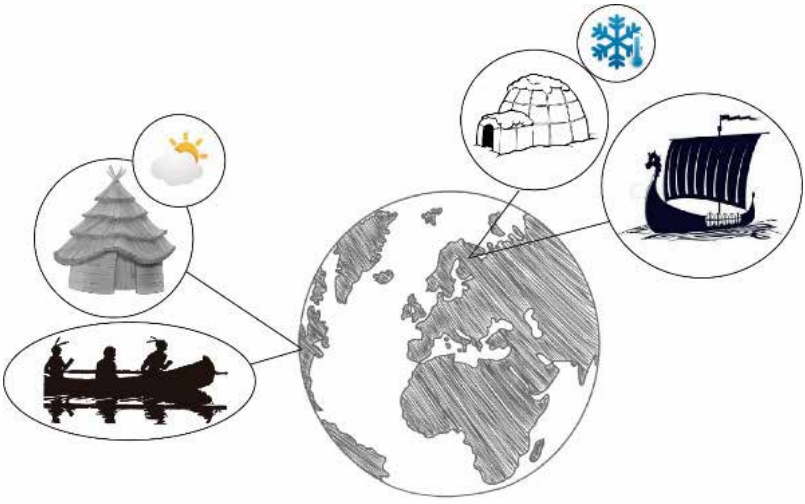

Figure 7. Innovation and sophistication spark from difficult situations

In Figure 8, it is shown an example of how innovation is the result of a complex system of thoughts which benefits from stressors, such as environmental conditions. The easier a situation is, the less innovative a solution will be. In the image, it is shown how climate situations, and resources availability leaded to different levels of innovation in tropical regions where weather and temperatures are relatively stable, compared with Nordic areas where cold temperatures and lack of resources leaded to complex structures for both transportation and housing.

Figure 9 presents a clear example of how the local context, including knowledge and resources available, can be used to create a solution. In many developing countries, with limited resources and inexperience stuff, high-tech medical equipment like incubators result to be useless after a short period of time, as they cannot be repaired by locals when breaking down. There are still some artefacts that due to their essential role in daily life, like trucks, are kept working thanks to the availability of pieces and components, plus the technical experience of locals.

NeoNurture designers, make use of local information, plus technical knowledge, in order to overcome the challenges of complex high-technological incubators developed for first world countries. “The incubator uses sealed-beam head-

lights as a heating element, a dashboard fan for convective heat circulation, signal lights and a door chime serve as alarms, and a motorcycle battery and car cigarette lighter provide backup power during incubator transport and power outages" (designthatmatters.org, 2017).

Figure 10. NeoNurture, incubator made with vehicle parts

Other examples are, Shokti Doi: a high nutritional yogurt developed by Grameen Danone Foods Ltda., thought to supply the basic nutritional requirements of children living in poor areas of India and Bangladesh, as a solution for the high rate of undernourished children who were unable to receive basic nutrients to guarantee the correct development of brain, affecting their learning ability. The product is produced using local supplies, in factories inside the core problem

area, in order to bring job opportunities to the people leaving in the affected communities and sold at an affordable price (Grameen Creative Lab, 2017).

4.3. In Social Systems, Diversity, and Collaboration in Liquid Networks are Essential to Promote Creativity.

Adopting the idea of Gilles Deleuze and Felix Guattari for whom ***social units are fusions, or couplings of 'people-groups-things-ideas'*** in what is called ***social flow*** (Dolwick, 2009), social systems, which ***self-organize, multiply and replicate*** with the necessary elements to be classified as antifragile complex systems (Taleb, 2012, p. 68), require ***diversity and liquid networks***, to promote the merge of different ideas and perspectives, giving place to serendipity moments where innovation and creativity appears (Dolwick, 2009). Under those conditions, ***the adjacent possible***, the set of alternatives to deal with specific challenges is wider than those of ***productive, stable and predictable environments*** within which the social flow happens without stressors (Diamond, 2012, p. 41).

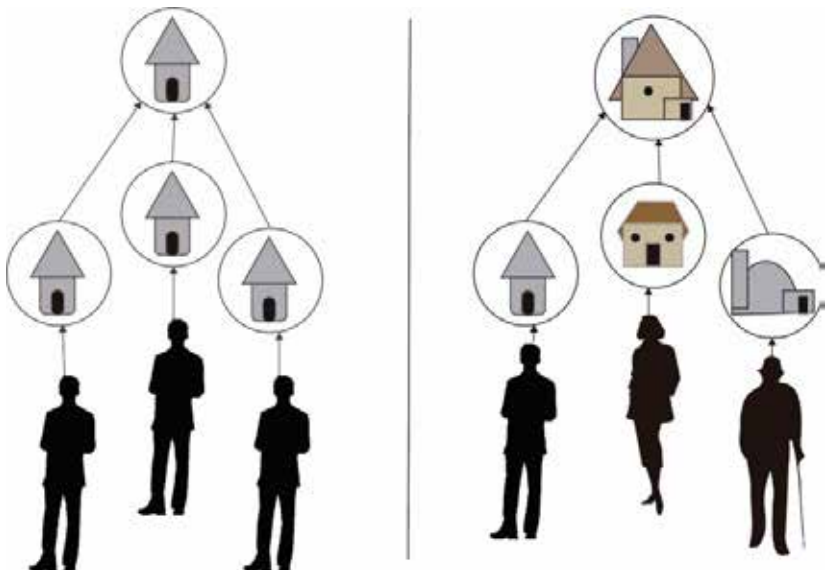

Figure 11. In social systems, diversity, and collaboration in liquid networks are essential to promote creativity

Figure 12 presents diversity and liquid networks, as a catalyst of innovation. On the left side, homogeneity of thoughts ends up in the same ideas while on the right side, different perspectives, promote creative ideas.

By involving designers, technical staff, doctors and mothers, the organization Designthatmatters.org, an effective new-born phototherapy device for low-resource hospitals was developed. It is called Firefly Newborn Phototherapy (See Figure 13). According to its creators, "firefly provides high-intensity phototherapy that is 'hard to use wrong'- in other words, the device eliminates the most common sources of product failure...Through research it became apparent to our design team that existing phototherapy devices are easy to misuse, resulting in many cases where jaundice is not treated effectively… The device fits one infant instead of many to reduce the risk of cross infection and reducing ineffective doses of phototherapy for infants treated.

By integrating the infant bed into the overall design and placing the lights at a non-adjustable, fixed distance, Firefly prevents users from providing ineffective doses of phototherapy to infant and prevents hospitals from placing multiple infants in the device." (designthatmatters.org, 2017).

Other examples are: World Wide Web: "the world wide web by Tim Berners-Lee following his employment by CERN in 1982. The www was started as a hobby to keep track of the people and projects there, but it took until the late 1980s for the initial hunch to be remixed with other platforms and to build on the developing internet. There was something in the research environment at CERN that allowed the idea to mature and be kept alive until the world was ready for it" (Hos-McGrane, Liquid Networks, 2013)

Multipurpose jacket: A jacket that works also as a bag and a blanket for homeless people, designed by a group of 17 students from different backgrounds ranging from architecture to law, exemplifies how without following an specific framework, defined material or brand philosophy, but rather following only a final purpose of creating an element to help homeless people in Bogotá, Colombia, an innovative idea arose (Rojas, Jóvenes diseñaron una prenda para los habitantes de la calle, 2017)

Figure 14. **Firefly new-born phototherapy**

5. PRINCIPLES FOR INNOVATION FOR DESIGN THAT CONSIDERS SOCIAL ASPECTS

"Necessity may be the mother of invention" Geoff Mulgan

A suggested set of 11 principles intended to improve innovation, reduce fragility and moreover, lead to feasible and useful solutions in the systems we design to tackle social problems is presented. It is worth mentioning that in this work, products are seen as part of innovation systems, complex by definition, to the extent that they can multiply and replicate, thus capable to be classified as antifragile systems.

The following is a list of proposed principles which evolve around four key elements to have innovation in social design: actors, tools, place and local context. Those principles are necessary but not sufficient to promote innovation in the context aforementioned.

1. Consider the problem context, opportunities and limitations

The best catalyser of innovation is a problem, but in order to make an innovative idea, useful, feasible and sustainable, it should be developed the nearest possible to the core problem. This means analysing the local constraints, stressors, tools, resources, state of knowledge from their locals, and any other element regarding opportunities and threats, necessary to guarantee the solution sustainability, continuity, replication and improvement once implemented.

2. Stick to simple rules

As mentioned by Taleb, "Complex systems do not require complicated rules – in fact, the simpler the rules the better. We must resist the temptation to respond to complexity with complex rules – they have a disturbing tendency to produce cascades of unintended consequences." (Sterling, 2013).

3. Ration the supply of information

In order to prevent the undesired effects of interventionism, Taleb suggest reduce the supply of data, giving less place to noise and biased decisions. It is known how the more information a person receives, the more

difficult is to take decisions, for example when choosing for the desired ice cream and having hundreds of flavours under disposal.

4. Design by layers

The antifragility of a solution increases when it can get feedback from layers, that is, previous ideas that might seem unfeasible when confronted against stressors (i.e. hard conditions, context, etc). In this principle, dividing the design idea into parts, and evaluate them when subject to stressors, then iterate the same process over and over again, might help to define whether the solutions are suitable for the whole system or not.

5. Build in redundancy and overcompensation

Nature is the best example of how redundancy is a key element to survive in cases that exceed the so-called worst-case event. "Nature repairs for what has not happened before, assuming worse harm is possible." (Taleb, 2012, p. 58). That is the reason why we have two kidneys instead of only one. Thinking the design solution as a system, consisting of interrelated parts, those which seem to be more fragile, the so-called bottlenecks, should be provided with more overcompensation, so that the whole system can survive in case of any disruption.

6. Resist the urge to suppress randomness

As mentioned by Taleb, efforts to eliminate volatility, randomness, and stressors will only create undercompensation, intensifying the vulnerability of systems to damage from disruption, especially those related to unpredicted events or so called Black Swans. Without randomness, there can be no serendipity. "…innovation and sophistication spark from initial situations of necessity, in ways that go far beyond the satisfaction of such necessity (from the unintended side effects of, say, an initial invention or attempt at invention)" (Taleb, 2012, p. 55).

7. Give importance to practitioners rather than only theoreticians

Taleb asserts that "practitioners are too busy doing, so they don't have the time to write their own story" (Sterling, 2013).

To provide a contextualized solution and guarantee its continuity in the core of the problem, it is necessary to feed ideas with the cumulative ex-

perience, knowledge about specific constrains, resources, and in general problem context that can only be reached by involving a sample of the affected individuals, into the design process. The affected group, in the end, are those who essentially will face the effects of the provided solution and who will reproduce and/or improve it in the future.

8. Co-create with actors from different generations and backgrounds

The more diverse the involved group is, the more chances for liquid networks to happen. Diversity promotes the merge of different ideas and perspectives, giving place to serendipity moments where innovation and creativity appears (Dolwick, 2009). Under those conditions, the adjacent possible, the set of alternatives to deal with specific challenges is wider than those of productive, stable and predictable environments constrained to only certain group of participants, who by having similar knowledge and backgrounds, more likely will come up with similar ideas.

Such a co-creation process, is intended to cover the four levels of creativity (see table 3): Doing, adapting, making, creating. According to Sanders & Jan Stappers, users can become part of the design team as 'expert of their experiences', as long as they are provided appropriate tools for expressing themselves. (Sanders & Jan Stappers, 2008, p. 12). Those tools should look for:

- Lead people who are on the 'doing' level of creativity,
- Guide those who are at the 'adapting' level,
- Provide scaffolds that support and serve peoples' need for creative expression at the 'making' level, and
- Offer a clean slate for those at the 'creating' level.

9. Make use of diverse emergent platforms

Emergent platforms, that is the previous ideas, tools, developments and innovations generated by other individuals, to handle other similar or different challenges, are essential to start from a basis. Additionally, knowledge diversity in terms of approaches, backgrounds and contexts provide opportunities for seren-

dipitous connections to exist.

In this principle, tools take a decisive role, as they can define the method to be used. Providing and/or suppressing tools and technologies, can lead to more adaptable solutions, that can easily be replicated and transformed on time.

10. Avoid interventionism

As mentioned by Steven Johnson, different patterns of innovation such as liquid networks, slow hunches, serendipity, noise, exaptation and emergent platforms, do best in open environments where ideas flow in unregulated channels (Johnson, 2010, p. 244). Interventionism, even the naive one, such as a methodology proposal, tools supply or work area organization, can lead to iatrogenics, and can influence ideas preventing them to evolve unconstrained. To mention an example, wood craft work, is in general characterized by apparently disorganized work areas, that allow the crafters to create without constraints. If a method or a tool is restricted to a specific purpose, there is no place for exaptations, i.e., finding a new function apart from its original one.

11. Design in environments full of juxtapositions

Creative spaces, to promote serendipity (moments of unexpected relevance, in which ideas are generated without looking for them), should involve juxtaposition, that is the arrangement of seemingly unrelated elements such as tools, environments, thoughts and ideas to create ecosystems where new connections of ideas can happen.

As cited by Silva (2014), "Juxtaposition is revelated as the basic formal operation of synchronicity, as two apparently unrelated events or elements suddenly form a secret link that strikes in the mind of the perceiver, an evanescent lightning bolt of meaning (Davis, 2003)". Silva also explains how juxtaposition environments can be enhanced by programming the designer's mind using Psycho-Cybernetics, a way to program one's brain to seek out some patterns to solve a given problem. Examples of psycicibernetics are writing down the idea to be deeper developed and check it before going to sleep. Then, the next day, review that idea and immerse oneself in an environment with juxtapositions. It can lead to see new patterns that eventually could complete the idea.

5. PHASE 4 AND 5. EVALUATION

In this phase, a comparison between the proposed principles and those already existing in the design-related literature is made, in order to identify differences and similarities that lead to a richest framework for practitioners interested on innovation in social design. The benchmarked works were selected judging by their popularity in the given context, and their successful application cases around the world.

DISCUSSION

• The primary purpose of this study was to present a set of principles to promote innovation during the design process of solutions intended to solve or mitigate social problems, based on a non-purely design perspective, by reviewing literature on different areas, and ultimately compare and contrast them with some of the main current research on the topic, focusing on those organizations that have had the chance to implement and test their ideas. To come up with the main ideas of this work, a Theoretical Triangulation process was implemented combining statements from different authors belonging to different knowledge areas. However, by following the mentality of "more is better", during the triangulation process, materials that did not bring much to this work were examined compromising the whole efficiency of the study. That is one of the disadvantages of the so-called Theoretical Triangulation process, which as brings such a huge range of possibilities, it might fail on the dependency of subjectivity when selecting the sources.

• During the theoretical triangulation process, the selected authors, although were based mainly in the suggestion of an academician and practitioner on design, depended on the advisor's expertise. A different set of authors, would most probably end up in a different set of principles. Additionally, the ideas chosen from each author to create the triangulations, were subjective, seeking for supporting a hunch regarding the covered problem. As cited by Thurmond, "Findings do not become more valid and credible simply because they were supported by similar theories, which may have interrelated constructs and concepts (Lincoln & Guba, 1985)".

• Once completed the triangulation process and generated the set of principles, when contrasting it with the current state of art, it was hard to identify whether the authors were referring to social innovation or innovation in social design, as each of them define their goals using different words. For some, design intended to solve social issues, is part of what is called human centered design, while for others, it is part of a greater goal which is a social change. Finally, the literature used to compare and contrast with the proposed principles, although were based on the popularity on search engines regarding topics such as "social innovation", "social design" and "innovation in social design" as well as by their application on real problems, their selection also might have fallen into subjectivity and might have excluded other richer ideas not covered here.

• Finally, measuring the effectiveness of the proposed work, even if it involves a practical application, is hard, considering that there are not standardized KPI's for innovation in social design or social innovation based on other than the profits generation. Also, the impact of an innovation intended to cover a social issue, depends on its continuity, adaptation and replication, which requires time and might depend on many factors that vary from context to context.

CONCLUSION

• The proposed principles extracted from the theoretical review can serve as a complement for other frameworks or guides to promote innovation in product design pursuing the solution or mitigation of social problems such as disaster relief, homelessness, hunger, poverty and associated topics such as sheltering, pedagogic resources, healthcare systems or even water supply for vulnerable communities.

• Promote innovation not only in the design team but also in the community members who in the end are the ones who implement, give continuity and improve the solutions to social challenges. Innovation is the key aspect that should be provided to the communities. Innovative communities can create products seeking not only for functionality and usability but also to reach pleasure in any of its conceptions.

• Simplicity, which is mentioned in the second suggested principle, and as recognized by the Young Foundation is one of the necessary elements to guarantee the spread of an innovation. The simpler an idea, the easier it can be presented to the different actors or stakeholders involved, from the community itself, till organizations or governments interested on supporting and promoting it.

• Understanding the context where the problem situations evolves, as recognized by Dorst, IDEO.org and The Young Foundation, is essential to create a "something" for "someone" rather than simply replicated what was created for others. By immersing into the problem context, more than simply creating empathy, a better understanding of the situation themes can be reached, thus a feasible solution can be created.

• Although many of the principles developed in this work were previously developed by other authors, some in more detail, and others in different words, it is worth to highlight how starting from a different perspective regarding innovation and its role in human evolution, allowed a similar set of ideas. Organizations such as IDEO.org or The Young Foundation which have developed practical projects allowing them to test and improve their assumptions, have created a full set of strategies to guide design teams to create and implement good solutions to social issues. However, the role of designers is still strong, being the community participation a source of input during some phases of the whole design process. This point of view is changed in this work, where a more active participation of the real practitioners who in the end will define whether the idea continues or not, is suggested. Now it is time for those and other organizations to test the proposed assumptions in a real context.

Table 1. Comparison between existing theories and the proposed design principles

	THEORIES EVALUATED			
	Proposed principles	**Dorst: lessons from design**	**IDEO.org: Human-Centered Design framework**	**Young Foundation: Ways to design, develop and grow social innovation**
Elements	1. Consider the problem context, opportunities and limitations 2. Stick to simple rules 3. Design by layers 4. Build in redundancy and overcompensation 5. Resist the urge to suppress randomness 6. Give importance to practitioners rather than only theoreticians 7. Co-create with actors from different generations and backgrounds 8. Make use of diverse emergent platforms 9. Avoid interventionism 10. Design in environments full of juxtapositions	<u>Expert's practices:</u> 1. Coevolution 2. Developing problem situations 3. Handling frames 4. Exploring themes 5. Fostering a discourse	<u>Mindsets:</u> 1. Creative Confidence 2. Make it 3. Learn from failure 4. Empathy 5. Embrace ambiguity 6. Optimism 7. Iterate, iterate, iterate <u>Phases:</u> 1. Inspiration 2. Ideation 3. Implementation	<u>Stages of social innovation:</u> 1. Coevolution Prompts, inspirations and diagnoses 2. Proposals and ideas 3. Prototyping and pilots 4. Sustaining 5. Scaling and diffusion 6. Systemic change -
Participants	**Design team, targeted people**	**Design team**	**Design team, targeted people, partners, investors**	**Design team, targeted people, partners, investors**
Detail level	Low	Medium	High	High

	Proposed principles	Dorst: lessons from design	IDEO.org: Human-Centered Design framework	Young Foundation: Ways to design, develop and grow social innovation
Highlights	The proposed principles aim to promote innovation in design contexts where the generation of new ideas appears to be critical but where repetitive solutions continue being applied. That is the case of designs intended to tackle social issues, such as those faced by communities in developing countries where traditional products and approaches might not be appropriate. Special attention is payed to the active role that the community can play during the whole design process and implementation, reason why the tools, and methods should be simple and easy to understand by people from different backgrounds and knowledge. The co-creation between direct affected actors, experts, and members of the design team, is presented as a proper environment for serendipity moments to happen, where new and even crazy ideas can be created. Understanding the social problems as antifragile systems, where certain level of uncertainty and randomness might be helpful to make adaptable solutions, is another important contribution to the state of art.	Framing is presented as an important step to counteract a paradox, it means, looking at problems from broader contexts and not only the one from which it was originated. Dorst describes how ideas generate in a process called coevolution, for which it is necessary to identify key concepts that lead to building a bridge between the problem space and the solution space. Also, the importance of developing problem spaces by shifting the definition of the problem, highlighting a future context. To innovate, it is necessary to weigh the assumptions leading to an original solution. It is also suggested to guide others to arrive to a definite frame, rather than suggesting a new frame directly, as the former one will lead to their desired solution and not an imposed one. Themes are also presented as key information sources to create something for someone, and getting immerse into the problem context, is suggested to bring clues to find those themes that led to a better understanding of what is really needed.	During the inspiration phase, interviews, both individual and as a group are a essential tool to understand people's hopes and desires. A deep involvement of the design team with the daily life of the community is advised. The ideation phase is characterized by a co-creation process involving some representative individuals from the community to work jointly with the design team, as well as other partners. Prototyping plays an important role to get feedback. Finally, the implementation phase makes emphasis on the feasibility and sustainability of the solution, by ensuring resources and performance measures. IDEO.org provides detailed materials like interview forms and diagrams samples to perform step by step the design project.	In the first stage, the importance of critical situations as catalysed or innovation is presented. Once there is such a situation that justify an innovation, as well as the inspirations for it, the community should participate actively in the whole design and implementation process. Alike IDEO.org, the Young Foundation recognizes the importance of Ethnographic Research Techniques and the involvement of the researcher in the daily life of people, to identify what they really need and want. The authors also agree with the proposed principles, regarding the importance of alternative creative spaces to generate ideas. In this case, walking in the targeted area is suggested. For the second stage and the fourth, they suggest the use of Proprietary Knowledge applied to social issues, such as the Grameen associations. In the third stage, trial and error as well as prototyping are suggested. Effective supply and demand of the innovation, is essential for its scaling and diffusion. Ideas should be also simple to reach a greater scope.

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Chapter 3

GENDER DIFFERENCES IN SPATIAL COGNITION AND SOCIAL EQUITY BY DESIGN EDUCATION

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This research focuses on the gender differences in terms of cognitive abilities with regards to spatial reasoning, how designing activity might affect those differences, and whether design education can be a medium for social equity.

Some of the early researches on cognitive differences of genders which are intended to prove male superiority mentioned in the Holy Scriptures, were conducted in the 18th century. Those pioneers were scientifically inadequate due to the assumptions were rooted in intellectual capacities by measuring and comparing the cranium of men and women and the size and weight of the brains (Walker, 1850). Based on the data that indicates males' brains are heavier than females, researchers concluded that women are inferior on spatial cognition.

Although there are many reliable and valid contemporary research on cognitive abilities in the context of psychology, neuropsychology and endocrinology, the bias against the cognitive abilities of women still exist. Yet, with the help of new imaging technologies such as positron emission tomography and functional magnetic resonance, contemporary research in neuropsychological and endocrinology disciplines revealed that there are more cognitive similarities than differences between genders. In psychology, these findings led researchers to focus on cognitive abilities with the hypothesis of the gender differences in intellectual functions seem to lie in the patterns of abilities which are influenced by many variables such as culture, self-perception and hormones, rather than in overall intellectual functioning (Weiss et al., 2003).

Psychological researches on gender differences are focus on mathematical, spatial and verbal abilities as the most drastic differences found in these. In particular, men have an advantage in rotating an object or manipulating it through imagination in addition to navigating their way through a route; women tend to be better at perceptual speed, recognizing landmarks and faces (Ellis, 2011; Vecchi and Girelli, 1998). Although the results of the researches indicate that men are superior to women on mathematical and spatial abilities whereas women are superior on just perceptual skills (e.g. Shepard and Metzler, 1971; Vandenberg and Kuse, 1978; Voyer et al., 1995; Beatty and Duncan, 1990; Rilea et al., 2004; Robert and Longpre,2005; Signorella et al., 1989; Tremblay et al., 2004; Voyer et al., 1995; Just and Carpenter, 1985), there are sceptical researches that criticize the methods used in those researches which favour male superiority (e.g. Caplan et al.,1985; Lunneborg, 1982; Richardson,1994; Subrahmanyam and Greenfield,1994). There are also researches claim that spatial ability training might bridge the gender gap in cognitive activities (e.g. Feng et al., 2005; Castel et al., 2005; Green and Bavelier, 2003, 2006, 2007; Law et al., 1993; Baenninger and Newcombe, 1989; McClurg and Chaille, 1987).

As stated above, if the social inequity on the nurture of genders in spatial abilities is the reason for the differences; it can be eliminated by education. In design-related disciplines, several courses aim to teach spatial abilities to students no matter their genders are. Thus, such courses can be a medium for achieving social equity.

SPATIAL COGNITION

Spatial ability refers to the capacity to imagine and manipulate objects in three dimensions (3D), and "generally, it refers to the ability to imagine what an irregular figure would look like if it were rotated in space or the ability to discern the relationship between shapes and objects" (Halpern, 2000, p.129). Spatial abilities subsume problems or tasks that require people to predict and/or judge the relationships among objects or the parts of them in different contexts (Elliot and Smith, 1983). Also, spatial abilities are accepted as the main abilities of construing imagery objects, creating mental images, making drawings, forming and visualizing mental

images as designs (Gardner, 1985; Rhoades, 1981). Thus, this ability is the core for engineering, designing, performing surgeons and driving, which are the strong masculinity symbols (Connell, 1987). The unwillingness of patriarchal science society to accept the fact that there are no gender differences arisen from nature on spatial cognition might be rooted in the fear of losing these masculinity symbols and also the male domination on spatial ability dependent specialized fields.

Despite the progress in spatial cognition researches, the concept has remained vague, and there is still no consensus on how to measure spatial abilities. Yet, the related researches in gender studies can be grouped into three categories. Linn and Petersen (1985) named these three categories as *spatial perception*, *mental rotation* and *spatial visualisation*.

Spatial perception is defined as the ability to comprehend and perceive spatial relations and links even if there is a lack of information. The common measures of spatial perception are Rod and Frame Task and the Water Level Task. According to researchers, the gender difference in spatial perception emerges at prepubertal ages, and there is a moderate difference, mean d=0.44, with men outperforming women (Vederhus and Krekling, 1996). Yet also, there are a few researches that conclude there are no gender differences (Desmond et al., 1994; Robert and Tanguay, 1990).

Spatial visualisation is defined as the ability of mental manipulation of complex spatial information, which demands solving different levels of spatial problem stages in an imaginary 3-D space and creates a representation of the object from a new viewpoint (Linn and Petersen, 1985). The common measures of spatial perception are the Embedded Figures Test, Block Design Test, and the Mental Paper Folding Test. In general, the results of researches indicate that there are relatively low gender differences, mean d = 0.19, favouring men (Linn and Petersen, 1985).

Mental rotation is defined as the ability of mental rotation of objects in a two or three-dimensional imaginary space related to a person or an object. According to Kolb and Whishaw (2000), mental rotation is also the ability to assume invisible sides of things and adopting novel perspectives. The common measures of mental rotation are Paper–pencil tests, Vandenberg– Kuse Mental Rotation Test, which uses Shepard–Metzler 3D cube figures and the 2D Card Rotation Test. According to Linn and Petersen (1985) and Voyer et al. (1995), the largest gender difference found in mental rotation tests and tasks; mean d = 0.94, indicating men outperforming women.

CATEGORIZING THE RESEARCHES OF GENDER DIFFERENCES ON SPATIAL COGNITION ACCORDING TO THEIR RESULTS

The researchers claim that there are gender differences on spatial cognition highlight the effect of hormones; while oestrogen negatively affects spatial ability, testosterone has a non-linear effect (Alderton, 1989; Harris, 1978; Imperato-McGinley et al., 1991; Kimura, 1996; Moffat and Hampson, 1996; Nyborg, 1983). According to another biological theory, the X-linked recessive gene, the X chromosome is the determiner of spatial abilities (Bock and Kolakowski, 1973; Stafford, 1961; Vandenberg and Kruse 1979; Walker et al. 1981; Yen, 1875). Yet, later research, such as Boles (1980) and Gittler and Vitouch (1994) refute these theories through comprehensive reanalyses by proving that there is no effect of hormones or gender-specific genes on spatial abilities.

Some researchers claim that gender differences might be observed due to a lack of methods in use. According to Caplan et al. (1985), gender differences that found are consequential, and tests and tasks that are used to determine them are inadequate to measure spatial abilities. Lunneborg (1982), Richardson (1994) and Subrahmanyam and Greenfield (1994) argued that the Western cultures accept spatial tasks masculine, and develop the tests with a biased approach. Thus, Lunneborg (1982), Richardson (1994) and Subrahmanyam and Greenfield (1994) suggested that if the tasks and tests engendered, differences might be minimized or even evanished. Crawford et al. (1995) claim that unsubstantial gender differences in spatial abilities phenomenon observed due to gender-biased instructions on the tests. Goldstein et al. (1990) and Stumpf (1993) assert that the mental rotation tests' and tasks' results might be fraudulently boosted on the behalf of males. Linn and Petersen (1985) and Voyer et al. (1995) indicate that the spatial tests and tasks have undeniable effects on results, thus, the methods should be selected and applied with caution. Indeed, Voyer et al (1995) show that the results of the spatial ability research are highly dependent on the type of the test used; the use of more masculine objects tends to affect results in favour of males. Goldstein et al. (1990) bring it to light that if participants have enough time to answer all test/task items, the gender differences disappear; hence, spatial ability differences might be observed only because of reaction times and might be inexistent at all. Collins and Kimura (1997) claim that gender differences might be observed because of the

difficulty of the tests. Paivio and Clark (1991) criticize the tasks by claiming the tasks should be reformed according to the static versus dynamic nature of mental images.

Although the existence of gender differences in spatial ability is widely accepted, there is still no consensus on its underlying reasons. As it is summarized above, the reasons might be the nature of human, the nature of the methods or as given below, the nurture of human which is the third category of spatial research perspectives that promote the idea of gender differences in spatial abilities can be eliminated by equal training and education (e.g. Rovet, 1983). Kass et al. (1998, p.338) states that,

> "Whether or not spatial abilities are biologically determined, they are certainly differentially reinforced throughout childhood and into adulthood. Boys have been traditionally steered toward classes in math and science; have been encouraged to participate in sports; and are more likely to train for careers requiring highly developed spatial abilities, such as pilots, engineers, and architects. Despite the compelling genetic and hormonal theories previously discussed, it seems that with such strong social encouragement to excel in visual-spatial tasks, the supposed biological advantage for men may be only a minor contributing factor in the explanation of gender differences. As the education and experiences of men and women become more shared, the differences in spatial ability should become less pronounced."

Berry (1971) states that certain spatial abilities developed by the pressure of cultural adaption since he found a remarkable difference between the spatial abilities of mountainous ecology inhabitants and plane ecology inhabitants. In Belz and Geary's (1984) research, SAT scores have been analysed in the context of cognitive abilities and found that father-absent children showed significantly lower mean quantitative scores than father-present children. Brownlow et al. (2003) suggest that women's poor performance might be due to the negative social stereotypes, which declared that women could not get better grades than men on spatial ability tests. Crawford et al. (1995) compared the performance results of the women informed about what the tests measure and the women uninformed, and the results showed that the informed women are negatively influenced and thus performed low. In the same study, Crawford et al. (1995) conclude that the gender differences are rooted in social stereotypes, and playing with gender-spe-

cific toys, such as Lego and Barbie's, seem to form spatial abilities. Consequently, women's inexperience and unfamiliarity with spatial tasks are interpreted as men's superiority. Another research on gender experiences belongs to Ginn and Pickens's (2005), in their research they analyse the mental rotation test scores according to backgrounds of the participants, such as art and athleticism, and they found that women who experienced those fields also scored higher at mental rotation test like as their male counterparts, so they conclude that practice is a crucial factor affecting the existence of sex differences in spatial abilities. There are also researches claim that playing computer action games, such as MMORPGs (Massively Multiplayer Online Role-Playing Games) reduce gender differences in spatial skills(e.g. Feng et al., 2005; Castel, et al., 2005; Green and Bavelier, 2003, 2006, 2007; Law et al, 1993; Baenninger and Newcombe, 1989; McClurg and Chaille, 1987). Feng et al.'s (2005) two-stage experiment indicate that after only 10-hour action-video-game training, women got better scores and the difference reduced significantly. Similar to this research, Saccuzzo et al. (1996) conducted a two-stage experiment to determine training effects on gender differences in spatial abilities; the results show that women catch up to men after training sessions. Merrill et al. (2010) researched the impacts of improving spatial abilities on geometric and trigonometric abilities by 3-D solid modelling training. Nordvik and Amponsah (1998) found that female engineering and technology students scored higher than female social science students on the spatial ability tests.

REFLECTIONS OF THE RESEARCHES ON DESIGN EDUCATION

As it is rendered above, gender differences in spatial abilities research can be categorized into three according to their results. The research fall under the first category investigates pieces of evidence for the existence of spatial ability differences between genders in the manner of biological characteristics without taking cultural, social and environmental features into account. The second category covers sceptics on the methods that are in use to measure gender differences in spatial cognition, without suggesting alternatives of those tests and tasks. Both categories do not exceed being stative and descriptive. The third category covers researches that promote training in spatial abilities to eliminate the gender differ-

ences in spatial abilities. Unlike the first and second ones, the researches fall under the third category is dynamic.

Spatial abilities are critical to success in design domains such as industrial design and architecture since drawings and graphical/spatial modellings are the media of non-verbal communications for conveying design solutions. The design process is a cognitive activity which requires producing consecutive mental representations of forms related to design solutions (Kim and Maher, 2008). Thus, the design education has many components to foster spatial reasoning that involves drawing, computer modelling and physical modelling. Design and spatial abilities are the systems that are feeding each other. By training on the spatial abilities with the help design courses such as Design Drawing, Graphic Communication, Computer Applications for Designers and Computer-aided Modelling, students' spatial abilities might equally improve, and doing so gender gap might be eliminated. Moreover gender differences in spatial abilities might not be observed among senior design students.

This research only reviews the literature and presents some presumptions that design education can be a medium for social equity due to its constituents that involve spatial reasoning training, and so there might be no gender-related spatial cognition differences among senior design students. Nevertheless, further research should be carried to find scientific evidence for the presumptions.

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Chapter 4

DESIGN FOR THE CIRCULAR ECONOMY: A CASE STUDY WITH INDUSTRIAL DESIGN STUDENTS[1]

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Design for the Circular Economy, which seeks a new stakeholder relationship in which products and services are more intertwined, unlike the linear economy, directly affects the responsibilities of the industrial designer. The traditional design, which tends to design for the end-user, is insufficient in the design for the Circular Economy, which needs to create a network and a system beyond the product. This study aims to develop inquiry tools to differentiate the product-oriented process in design education, empower the students to understand the new approach and use it in the idea generation process. This study was conducted through a design studio project focusing on the "futuristic charging station for electric vehicles" with senior year industrial design students taking the Product Design IV course in the 2017-2018 Fall semester. The study aimed to create inquiry tools that can be used in product design courses for the "design for re-use" and "design for recycling" approaches, which are the design principles for the Circular Economy. In the early design phase, the projects were given feedback to reveal potential corporate and private stakeholders relations where an established network was effective and meaningful. The students defined, outlined and developed ideas in

1 This study was presented as an oral presentation at the UTAK2020 Design and Foresight Conference held between 8-10 September 2020 with the title "Design for the Circular Economy: A Case Study with Undergraduate Industrial Design Students".

a specific scenario. Thus, the students were empowered to develop projects in this context. The authors, among which two of them were also the studio course instructors of the project conducted, analysed the two student teams' projects who considered "Design for Circular Economy principles" during the design process to create specialised inquiry tools that could be used for two Circular Economy principles. The principles addressed by the two teams were "design for recycling" and "design for re-use" in particular. Therefore, in this study, two inquiry tools for these two specific principles of "design for Circular Economy" are developed. In addition, Circular Economy's other design principles' inquiry tools which are "design for repair", "design for refurbishment", "design for remanufacturing", and "design for recycle" will be developed. These inquiry tools will be used and tested in future projects.

Keywords: Design education, design for the Circular Economy, design for re-use, design for recycling.

INTRODUCTION

A new economy is envisioned where services and stakeholders are more intertwined and related by transitioning from the end-user-oriented linear economy to the Circular Economy. IDEO co-founder Chris Grantham (2017) stated that designers and entrepreneurs tend to design for the end-user; the future design conception is design for the Circular Economy; therefore, he emphasises the need to change the design approach. An effective strategy for the Circular Economy is to design a more extensive system for a single user, rather than a single lifecycle, to create more value by interacting between multiple uses and users of the product. Therefore, the designer's responsibility is more than a single end-user focused solution or a single value in designing for the Circular Economy (Peters, 2017).

The creativity-oriented traditional definition of the industrial designer has evolved over time into a direction that develops successful business models, innovative products, systems, and experiences (WDO, 2015). Definition of successful business models, system, service and experience and the description of the new industrial designer, which points out that product design is much more than the concrete product, overlaps with the designer's responsibilities who is expected to take a role in the Circular Economy. If designers take responsibility from "object creativity" to "solution provider", they can contribute more to the Circular Economy (Meroni, 2008). While objects or products respond to the needs of users and society, they can also shape the economy when they take an active role in the system. Therefore, changing the roles of products in the system is important for developing the Circular Economy (De Schoenmakere and Gillabel, 2017).

Designers must now respond to different social, economic, and environmental needs and adopt a holistic approach to problem-solving. To this end, they must lead the development of the Circular Economy by changing design thoughts and practices and creating products and services that meet all the inherent criteria of the model (Andrews, 2015).

Due to the lack of knowledge and perception, and the inadequacy of product and user-oriented traditional design tools in design for the Circular Economy, it is rarely addressed by educational institutions, and designers cannot lead in the Cir-

cular Economy at the desired level. For this reason, more case studies on design for the Circular Economy should be conducted, and tools should be developed to construct a network, organise relationships, describe relationships in a specific scenario, and develop ideas that can be effective and meaningful.

This study aims to develop an inquiry tool that can be used in the early design phase of further projects by considering "design for re-use" and "design for recycling", which are the Circular Economy principles. Furthermore, with the inquiry tool developed with the deductive method, it is aimed that the students will design a more extensive system beyond a single product and user by considering the relations of the stakeholders within the system in future projects.

DESIGN FOR THE CIRCULAR ECONOMY

The linear economy refers to manufacturers', businesses' and consumers' "build, use, throw away" behaviour and directly focus on the end-user (EEA, 2013). On the other hand, the Circular Economy began to gain a theoretical footing in the field of industrial ecology in the early 1990s (Bocken et al., 2016). In 2014, the European Union Commission adopted the Circular Economic Package, including production, consumption, and waste management (Andrews, 2015). The European Union Commission associates the transition to a Circular Economy with strategies to increase recycling, prevent the loss of valuable materials, create employment and economic growth, move Europe to zero waste with new business models and eco-design, and reduce environmental pollution (Bocken et al., 2016).

The circular economy is primarily addressed in smart cities, as it draws more and more attention to the consumption and efficient use of resources. In the congress held under the name of SmartCity Expo in November 2018, some of the topics among the Circular Economy topics discussed in smart cities are blue economy, eco-design, recycling, low carbon, re-use, product as service, design for circularity, productive cities.

Relations in the Circular Economy are judged by the naturalist John Muir's approach that "when one thing in nature is displaced, the rest of the world depends on it" (Ferreira et al., 2019; Ellen MacArthur Foundation, n.d.). While developing new markets or expanding existing markets with the circular economy,

businesses are expected to reorganise their production and consumption strategies to efficiently utilise industrial materials, reduce costs, and prevent environmental pollution (Leube and Walcher, 2017). Therefore, it can be said that consumption relations in the Circular Economy should be rearranged within the system and with a holistic approach.

Stahel and Giarini (1989) and McDonough and Braungart (2010) described the flow of materials with the "cradle-to-grave" and "cradle-to-cradle" model to understand the difference between linear and cyclical approaches to the development of products and systems. This definition emphasised the driving force of design in the economy, claiming that "we do not have a waste problem, we have a design problem".

Chris Grantham (2017), one of the founders of IDEO firm, emphasises the importance of design in the Circular Economy with the phrase "design is central to the transition to the Circular Economy". The Ellen MacArthur Foundation (2015) states that the Circular Economy can be a restorative or regenerative industrial system with design. Design for the Circular Economy requires a more systems-based approach (RSA, 2014). The basis of this need is to increase the product's life, improve its circulation in a closed loop, strengthen the relationship between existing and new stakeholders and minimize the use of resources.

The development of alternative consumption strategies within the scope of the Circular Economy by large enterprises such as Caterpillar, Philips, Ford and Rolls Royce and smaller enterprises such as IKEA and the Bond Group has have not been adequately implemented due to the lack of know-how and comprehension of the content of the concept, as well as some obstacles and concerns in implementation (Andrews, 2015). One reason businesses cannot reach the desired level although incentives are given to develop new consumption and business models is that designers do not have sufficient knowledge and experience in applying circular design. Based on Schumpeter's (1942) statement, the faster the destructive creativity is, the faster the change will be. A rapid change is required for the transition to the Circular Economy in the design discipline (Leube and Walcher, 2017).

Design Principles and Exemplary Practices for the Circular Economy

Circular economy principles were explained with different definitions in the literature. For example, "design for product life extension", "design for maintenance", "design for re-use", "design for remanufacturing", "design for recycling", "design for disassembly" are the principles related to the design approach for the Circular Economy (Poppelaars, 2013). Table 1 shows the explanation of the different definitions of design principles for the Circular Economy. Although various definitions are used, it is understood that the end goals are similar.

Design for recycling is somewhat like sustainability. However, the main difference of the design for recycling, which is considered in the Circular Economy, from sustainability is that it deals with not only the product but also the whole stakeholders in the context for efficient use of resources and aims to renew business models by arranging the relations between possible stakeholders.

One of the Circular Economy principles, design for re-use, is focused on access rather than renting, sharing, owning for use by more people and includes multiple interconnected users and stakeholders.

Architect Thomas Rau, a corporate client of Philips, emphasised the importance of service rather than ownership with the brief he gave to the firm:

> "…I need a lot of light in my building every year. If you think you need a lamp, electricity, or whatever – that's fine. But I don't care about that, I just look at performance. I want light, nothing more…" (Ellen MacArthur Foundation, n.d.).

With this request, the user talks about a value beyond the product. In this context, how companies do in the future will be more important than what they do (Amitt and Zott, 2012).

Table 1. Design Principles for the Circular Economy (Poppelaars, 2013)

	Design for Repair	Design for Reuse	Design for Re-furbishment	Design for Re-manufacturing	Design for Recycle
Purpose	Restoring working conditions	To provide a 2nd, 3rd life to the product	To improve the quality level	Repair quality level as new	Just reusing the material
Method	Repairing damaged parts	Deliver-ing the product to other con-sumers	To replace worn or broken com-ponents by improving their quality or performance	To reproduce the entire product. Reusing the sub-components of the product in the same prod-uct family, in the same industry, or in another industry	Separating materials/ components

Table 2. Some design practices for the Circular Economy

Design for Repair	Design for Reuse	Design for Re-furbishment	Design for Re-manufacturing	Design for Recycle
	When selling light as a service, Philips develops services and products for lumen perfor-mance rather than the physical hardware of the bulb or fixture. With a fashion concept created by Mud Jeans, us-ers can rent jeans for a year.	With Phone-bloks, a Lego style smart-phone concept has been de-signed where parts of the modular mo-bile device can be replaced or upgraded in-stead of selling or throwing away the phone.	With Wear2 tech-nology, clothes can be broken down and repro-duced.	In cooperation with Ford and Heinz, waste toma-to skins are used in the auto industry. As part of the Net-Works program, in collaboration between yarn manufacturer Aquafil and car-pet manufacturer Interface, carpets are produced from discarded fishing nets.

With the Circular Economy, designers now can influence business models, consumer behaviour, and consumption, with the opportunity to lead a paradigm

shift. Therefore, they should anticipate and prepare for the alternative economy (Andrews, 2015). Some products and services developed based on design principles for the Circular Economy, which can be considered effective in changing consumer behaviour by developing new business models, are shown in Table 2. However, it can be said that these examples are insufficient in terms of designing a holistic system, discovering potential stakeholders, and arranging relations. The Circular Economy transition requires fundamental changes in production and consumption systems to go beyond resource efficiency and recycling waste (De Schoenmakere and Gillabel, 2017). The examples presented in Table 2 are primarily aimed at reducing waste or using resources efficiently. In these solutions, it is understood that the desired value contribution in economic relations cannot be achieved by focusing on a single product rather than creating an extensive system and network.

The shift towards a Circular Economy can only be achieved by creating value over a more extended period at the design level and creating business models for a wider stakeholder group to preserve that value. Business models determine the design of business activities and, therefore, products and services. (McDonough and Braungart, 2010). However, some designers need to change their practices for this to happen, while others need to change both their practices and their thinking (Andrews, 2015).

Design Education for the Circular Economy

IDEO (2017) states that the future of design is cyclical; that is, who/what design is designed for expands from a single user to an interconnected human network spanning the world.

IDEO co-founder Chris Grantham works with The Ellen MacArthur Foundation to design the Circular Economy in businesses and educational institutions. The Ellen MacArthur Foundation helped spread the transition to the new business model (MacArthur, 2013; Bocken et al., 2016). The organisation has critical information on the Circular Economy on its websites and in various publications; however, the information in question mainly focuses on producing and selling the enterprises' products. In addition, although the Circular Economy seems to be advancing at the societal level, it is still rarely found in the curriculum of design

education institutions (Leube and Walcher, 2017).

The Ellen MacArthur Foundation runs various programs at the high school and college levels to accelerate the transition and help understand the approach. Delft University was also included in these programs and applied a mobile phone project with an approach regarding "design for the Circular Economy" to design students (Jochemsen, 2015). Unfortunately, as there is a commercial agreement, the details of the project could not be shared.

Design for the Circular Economy in various educational institutions is often project-based rather than curriculum-based. However, to accelerate the transition and make the approach permanent, design for the Circular Economy should be included in the curriculum from the first year of design schools at the undergraduate level so that students may know that these principles should be at the centre of all design activities (Andrews, 2009; Andrews, 2015).

Design education institutions need to change their curricula quickly and radically for redefining design to be truly innovative for the Circular Economy, which requires a creative process where designers are not familiar and practical enough (Leube and Walcher, 2017). Moving towards the Circular Economy requires new thinking, skills and competencies in design. Chris Grantham (2017) evaluates that traditional design methodologies will be insufficient in the design approach for the Circular Economy; Andrews (2015) states that designers need to change design thinking and education so that they can consider the broader and long-term consequences of their activities in accordance with design for the Circular Economy. It can be said that the critical contents of the end-user and product-oriented traditional design approach in educational institutions should also change in this context.

Methodology: Idea Generation Tool for "Design for Re-use" and "Design for Recycling" in Circular Economy

The traditional design approach, which tends to design for the end-user, may be insufficient in "design for the Circular Economy", which needs to design a network and a system beyond the product. In this context, it is thought that it is crucial to develop an inquiry tool to differentiate the end-user and product-orient-

ed critical contents in design education and use the new approach before the idea development by students. Therefore, this study aims to create an inquiry tool that can be used in the studio course on design for re-use and design for recycling, which are the design principles for the Circular Economy.

This study was conducted in the futuristic charging station project for fourth-grade students in the 2017-2018 Fall semester at Eskişehir Technical University. The project asked the students to design an innovative charging station for electric vehicles for the Tesla Inc. Company by considering the tangible requirements of the whole system and intangible qualities such as brand identity and product semantics.

The total of the class was 24 students, and eight teams of three were formed. None of the students had previous experience with design for the Circular Economy. Instead, students stated that they heard this concept for the first time. For this reason, it was envisaged that the study on design for the Circular Economy would be implemented only with interested project teams.

At the end of the first week, the students were asked to present their research as teams on their approaches to transportation in the future. While some of the students have concluded that public transportation would be more common, some have reached the data that rental cars would be preferred more frequently. Some of them stated that they want to develop a project in this direction since individual passenger cars, which would still exist in the future, could be charged while they were in motion. All the students who were asked to have a futuristic approach preferred contactless charging for their station designs. They stated that contactless charging would be used in the future based on the findings from their preliminary research. Immediately after the project's research phase, an engineer on the subject of 'contactless charging' was invited to the university, and a seminar was organised. Thus, the students gained technical knowledge about contactless charging.

After the research phase, a presentation on "Design for the Circular Economy" was delivered to the students. The principles of design were explained with examples. Although not compulsory, the teams were asked to choose one of the principles and deal with the project. Two of the eight teams stated that they wanted to develop projects in accordance with the design for the Circular Economy. Therefore, the research was carried out on these two teams.

According to the research, one of the teams stated that they wanted to develop a project based on the "design for re-use" approach for charging rental vehicles. The other team addressed the design problem with the "design for recycling" mindset for charging the public transportation vehicles. During the early phase of the design process, for two weeks (four course days), after the completion of the preliminary research, the instructors gave feedback to the teams, making use of the questions and narratives found in the Circular Economy Guide and ECOVALA Circular Academy Tools, jointly prepared by the Ellen Mac Arthur Foundation and IDEO. The instructors focused on giving feedback in questioning and revealing potential new corporate and private stakeholders, arranging relations between them by constructing a network that could be effective and meaningful in terms of the Circular Economy, describing and defining relations in a scenario and developing ideas. In this way, the goal was to have the students define problems and develop ideas in this context.

The first project team learned that more public transportation vehicles will be used in the future and discussed the charging station project for buses. With the 'design for recycling' oriented critiques, Team 1 identified the energy generation required to charge the new generation buses as a design problem and sought solutions for the sustainability and recycling of energy. As a result of "design for Circular Economy" oriented critiques, Team 1 has developed the idea of designing a station that will provide continuous transformation of energy inspired by nature. The team, which placed the station in the city as a meeting point, aimed to design a station that transfers the magnetic electricity obtained from the walking movement of people to the bus and to meet the users' needs at the station during waiting and meetings. The public transportation stops and charging stations designed by Team 1, based on the motto of "movement for movement", aimed to obtain the electrical energy needed in public transportation vehicles by converting the mechanical pressure applied by the people in the station to the electrical power with the piezoelectric method used in the flooring. People walking on the electricity-generating ground were involved in the electricity production cycle by creating their own transportation energy. It was envisaged to charge the vehicle by transferring the energy taken from several arms on the ground to the vehicle from a point during stopping. Team 1 used the design for recycling basis only for energy production, which is considered a technical solution level. Team 1's project is shown in Image 1 and Image 2.

As a result of their research, the second project team stated that Tesla would

offer its electric vehicles to its users with rental service in the future and discussed the charging station project for rental vehicles and turned to design for re-use from design principles of the Circular Economy. Team 2 identified the space required for rental car charging stations as a design problem, with "design for re-use" oriented critiques. As a result of the "design for the Circular Economy" oriented reviews, the team has planned to organise the relations between new stakeholders by determining the parking lots of shopping centres as the stopping point for the vehicles. To develop a product that would meet the needs of all stakeholders in the system, they had developed the design idea of a charging unit that could meet rental, car parking and vehicle display services. While the rental process was carried out with the digital application in the charging unit where the parking lots of shopping malls were planned to be located, the vehicles were displayed thanks to the reflective surfaces of the charging units. It is aimed to use the shopping centre car parks as rental car galleries. As a result, it was aimed to develop a product that would meet the needs of all stakeholders by creating a meaningful relationship between the lessor, the lessor, the rental service provider, the Tesla Inc. company, the parking service provider, and the shopping centre stakeholders in terms of the Circular Economy. Team 2 has developed a rental service and system in which the charging station played an active role, created a new business model and relationship network, and met the needs of all stakeholders in this relationship network through the principle of design for re-use. Team 2's project is shown in Image 3 and Image 4.

Image 1. Team 1's project: Bus stop and charging station for public transportation, page1

Image 2. Team 1's project: Bus stop and charging station for public transportation, page2

Image 3. Team 2's project: Parking and charging station for Tesla rental cars, page1

Image 4. Team 2's project: Parking and charging station for Tesla rental cars, page2

After the projects were completed, the instructors prepared new questions by utilizing the information and questions found in the Circular Economy Guide and ECOVALA Circular Academy Tools, separating the questions and statements that might be suitable for design for re-use and design for recycling. The questions prepared and the two projects addressed were analysed with the deductive meth-

od. The questionnaire prepared for the projects and the answers are shown in Table 3 and Table 4. Two projects, which are tried to be analysed by asking precisely the same questions, could not answer the questions in the same way. While some questions regarding "recycling" could be answered in Team 1's project, some questions for "re-use" could be answered in Team 2's project. The questions, which were divided into principles according to their answerability, have been converted into more general sentences for making them applicable for new projects as well. As a result of the analysis, special inquiry tools were created for "design for re-use" and "design for recycling" principles. The two inquiry tools are presented in Table 5 and Table 6, respectively.

Table 3. Analysis of Team 1's project

Idea Generation Questions for the Design Approach for the Circular Economy	*Charging Station to be Designed for Public Transport Vehicles for "Design for Recycling" in the Circular Economy (Team 1)*
What is wrong with public transportation vehicles in the linear economy model? Is it possible to be inspired by nature for this problem?	Too much electricity consumption Renewable energy sources can be used to generate electricity.
What are the tangible and intangible resources in current public transport? Which resources are critical?	Electrical energy is critical.
What is the relationship between individuals, groups and organizations in existing public transport vehicles? What could be the network that could add value here?	-
What do you want to avoid in this project? What is your goal and what impact do you want your solution to have?	The goals are to reduce energy production costs, not to harm nature, to ensure efficient use of resources. It is aimed to make the waiting and meeting areas interactive with the bus stops and charging stations.
What is the difficulty of the design in your project?	Production of energy
What is the travel experience of the passenger with public transportation vehicles? How should/can it be?	-
What is the need of the charging station user? What are other ways to meet this need?	There are two stakeholders. Passengers need to provide transportation as soon as possible, while public transportation vehicles need to provide the necessary energy.

What would experiences be like in the context of the circular economy? How could costs be reduced?	Users could contribute to the generation of energy and costs could be reduced.
How can you ensure that the charging station for public transport stays in use longer? Can you offer the product as a service?	It can be used as social meeting areas. Bus stops can be created where people can meet some of their social needs.
How can you turn a charging station into a service for public transport?	with social assembly areas
What would it be like to offer the charging station as a service rather than selling it?	-
What might your service experience be and what stakeholders might you need? How do you build the relationship between these stakeholders?	-
What are other solutions that meet this need without having a charging station?	-
Identify the function the charging station is trying to solve, not the solution.	Social waiting and assembly areas that generate their own energy.
What are the stakeholders' needs and how do you meet that need?	Design of entertaining waiting and assembly areas and bus stop design for passengers who need protection from adverse weather conditions. Design of bus stop that can meet the electricity needs of public transportation vehicles.
Does the solution you find improve the experience?	The bus stop allows users to engage in short-term social activities along with their transportation needs.

Table 4. Analysis of Team 2's project

Idea Generation Questions for the Design Approach for the Circular Economy	*Charging Station to be Designed for Rental Vehicles for 'Design for Reuse' in the Circular Economy (Team 2)*
What is wrong with public transportation vehicles in the linear economy model? Is it possible to be inspired by nature for this problem?	-
What are the tangible and intangible resources in current rental service? Which resources are critical?	-

What is the relationship between individuals, groups and organizations in the current rental service? What could be the network that could add value here?	There is a direct relationship between renters and lessors.
What do you want to avoid in this project? What is your goal and what impact do you want your solution to have?	It is desirable to avoid having a charging unit in many places in the city and using it uncontrolled. It is aimed to analyse the locations of charging stations in a practical way and to serve these stations for rental.
What is the difficulty of the design in your project?	Where to locate the charging stations.
What is the rent experience of the users? How should/can it be?	Users communicate with renters by planning in advance. It could be a more unplanned driving.
What is the need of the charging station user? What are other ways to meet this need?	The user's need is to charge the rented car. The user wants to rent a car whenever he wants.
What would experiences be like in the context of the circular economy? How could costs be reduced?	Costs can be reduced by making the charging station more functional. An experience where the vehicle was used by more than one person on the same day could be designed.
How can you ensure that the charging station for public transport stays in use longer? Can you offer the product as a service?	The charging station can serve the rental service.
How can you turn a charging station into a service for public transport?	The charging station can serve the rental service.
What would it be like to offer the charging station as a service rather than selling it?	The charged area can be used as a parking area, as the car will be in standby while charging.
What might your service experience be and what stakeholders might you need? How do you build the relationship between these stakeholders?	The parking operator or the shopping mall is the lessor company, the lessor user. While the rental process is carried out with the application in the charging unit that is planned to be in the shopping mall parking lot, the vehicles are displayed thanks to the reflective surfaces of the charging units.
What are other solutions that meet this need without having a charging station?	To provide multiple use, to use by renting.
Identify the function the charging station is trying to solve, not the solution.	It is a system that allows the car to be displayed while charging and meets the parking area for the car.
What are the stakeholders' needs and how do you meet that need?	The lessor will want to use the car that is available for rent and that is charged, the lessor will want to display her vehicle.

Does the solution you find improve the experience?	It develops new rental and charging experience.

Table 5. Inquiry tool for "design for recycling" in the Circular Economy

"Design for Recycle" in the Circular Economy: Idea Generation Inquiry Tool *(Write your answers in the box to the right)*	
What is wrong with the linear economy model? Is nature inspired for this problem possible?	
What are the tangible and intangible resources in the current business model? Which resources are critical?	
What do you want to avoid in this project? What is your goal and what impact do you want your solution to have?	
What is the difficulty of the design in your project?	
What is the user's need? What are other ways to meet this need?	
What would experiences be like in the context of the circular economy? How could costs be reduced?	
How can you ensure that the product or material stays in use longer? Can you offer the product as a service?	
How can you offer your product as a service?	
Identify the function of the product or service that it is trying to solve, not the solution.	
What are the stakeholders' needs and how do you meet that need?	
Does the solution you find improve the experience? How does it develop?	

Table 6. Inquiry tool for "design for re-use" in the Circular Economy

"Design for Reuse" in the Circular Economy: Idea Generation Inquiry Tool *(Write your answers in the box to the right)*	
What is the relationship between individuals, groups, and organizations in the current business model? What could be the network that could add value here?	
What do you want to avoid in this project? What is your goal and what impact do you want your solution to have?	
What is the difficulty of the design in your project?	
How is the user experience? How should/can it be?	
What is the user's need? What are other ways to meet this need?	
What would experiences be like in the context of the circular economy? How could costs be reduced?	
How can you ensure that the product or material stays in use longer? Can you offer the product as a service?	
How can you offer your product as a service?	
What would it be like to offer the product as a service rather than selling it?	
What might your service experience be, and which stakeholders do you need? How do you organize the relationship between these stakeholders?	
What are other ways to meet this need without owning the product?	
Identify the function the product or service is trying to solve, not the solution.	
What are the stakeholders' needs and how can you meet that need?	
Does the solution you find improve the experience?	

Instructor Assessments of the Two Projects

The first team designed a system using recycling. They partially met the Circular Economy's requirements by addressing recycling and could not develop any design solutions for transportation services. It does not include the multi-stakeholders and the interaction between these stakeholders. There is no regeneration related to the transportation service. Still, the energy required during charging is provided by the stations, which are the meeting point, by using the potential of the assembly area.

The second team designed a rental service. In this sense, the design approach for the Circular Economy certainly exists. The relationship between the lessor, the lessee, the rental service provider, the Tesla car company, the parking service provider, and the shopping centre has been reconstructed, and a multi-stakeholder service with much more value has been incorporated. The students had no difficulty in bringing the stakeholders together. This relationship has directly affected the form and function of the product. Team 2's project was qualified as one of the best projects in the jury's evaluation to meet the requirements of the learning outcomes.

When the examples are examined and the results of student projects are evaluated, two different viewpoints emerge regarding the design for the Circular Economy. The results from Team 1's project can be summarised as follows:

1. The focus is on the product and its user.
2. It includes more limited stakeholders.
3. The product is in the foreground; a formula such as product > service can be created; The service serves the product.
4. The issue is how the product serves. In this framework, design is based on the Circular Economy principles.

In the results obtained from Team 2's project, the focus is on designing business models and services following the new design definition, and the fiction comes to the fore. According to this;

1. The focus is on service, service stakeholders and fiction.
2. Activities are planned among many stakeholders.

3. Service is in the foreground; a formula such as service > product can be created; The product serves the service.

4. Re-association with regeneration is made among all stakeholders.

5. Tangible products can be redesigned, or existing ones can be used.

6. A much larger cycle is designed rather than the product. The main issue is how the service is. Circular Economy principles can be used to get better results on the how question.

The information and questions in the Circular Economy Guide, jointly prepared by the Ellen Mac Arthur Foundation and IDEO, and the ECOVALA Circular Academy Tools are more complex and not specialised on a different basis. With this study, specific inquiry tools have been developed for design for re-use and design for recycling. Thus, these inquiry tools can be used to generate ideas and contribute to the transition to the Circular Economy. With the inquiry tools, students were provided with the opportunity to both comprehend "design for the Circular Economy" principles and develop ideas from different perspectives for design problems.

CONCLUSION

The new power of design in design for the Circular Economy focuses on the efficient use of resources and the sharing economy. The sharing economy creates the need to reorganise the relations between stakeholders. As Lucius Burckhardt (1980) stated, the value in these examples is not the house or the vehicles but the relationship between the stakeholders, the regeneration, and the tariff.

More practical and easy-to-understand methods and tools should be developed so that students can understand the new power of design. New approaches should be formed instead of the traditional design approach in design education to empower the students for enquiring and re-establishing the relations between the stakeholders. Unlike the product and user-oriented criticism, the students should be provided with the opportunity to question and reveal the potential corporate and private stakeholders, to organise relations between them by establishing a network that

can be effective and meaningful in terms of circular economy, to describe and define relations in a scenario, and to develop ideas.

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Chapter 5

DESIGN METHODOLOGY THROUGH ACTION RESEARCH AND HAAT MODEL: AN ASSISTIVE DEVICE DESIGN

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1. INTRODUCTION

Approximately 38% of the world population have some type of disability. Due to their disadvantages, they face difficulties in performing many actions in their functional capabilities, and they need products and technologies to perform these actions. The products and technologies help these individuals to perform in a higher capacity (WHO, 2019; U.S. Department of Education, 2004). The research on user expectations, experiences, and interactions is a significant part of the product design process (Norman, 2013:9). In the product design process, in which the disabled person is a user, the interaction between the user and the product may involve different parts of the experience. Therefore, assistive devices and user experiences should be improved with a comprehensive and systematic design methodology for the disabled. The research includes the design method that should be followed throughout the design process for a convenient product which helps disabled to perform, and the application of this method to the design process of an assistive product to be used in speech and language education of hearing-impaired individuals.

As a preliminary study, the conceptual project called Vitalk, which was carried

out in 2016 is the source of the research and master thesis[1] covering the education processes of hearing-impaired individuals, the design method proposal, and the application revealed within these processes (A Design Award, 2017). Based on the results of the project, Vitalk (2016) shows that the competencies of the educators, the individual efforts of the hearing-impaired students, and the support of their family members may not be sufficient for them to achieve success in primary language education. In order to find efficient solutions to these limitations, a research is planned to be conducted to propose a design method for the assistive devices. The researcher intends to advise and to evaluate alternative options so that speech and language education developments are implemented efficiently. Therefore, the research essentially answers these questions: '' how should the design process of the assistive device in speech and language education proceed, and what should be the research method for this process?''

2. DESIGN METHODOLOGY AND PROCESS

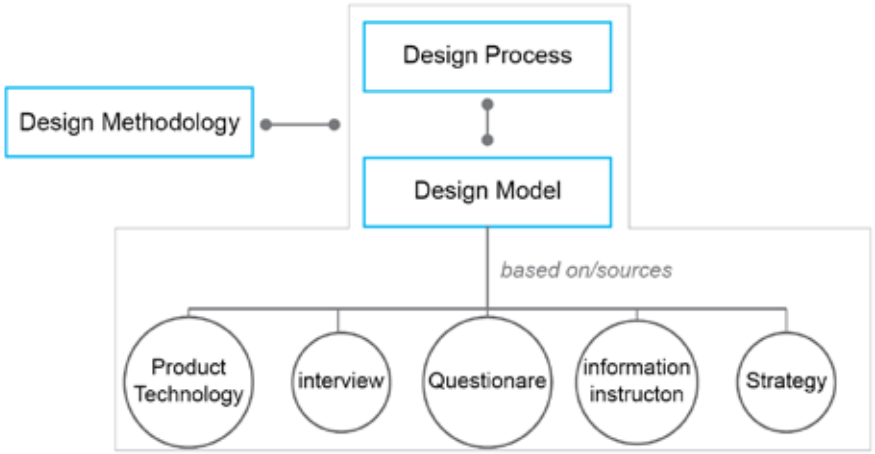

Figure 1. The flow chart of the methods used in the study

1 Uruc, A. (2020). *Design Methodology through Action Research and HAAT Model: An Assistive Device Suggestion for Hard of Hearing People.* Unpublished master's thesis, Gazi University, Ankara, Turkey.

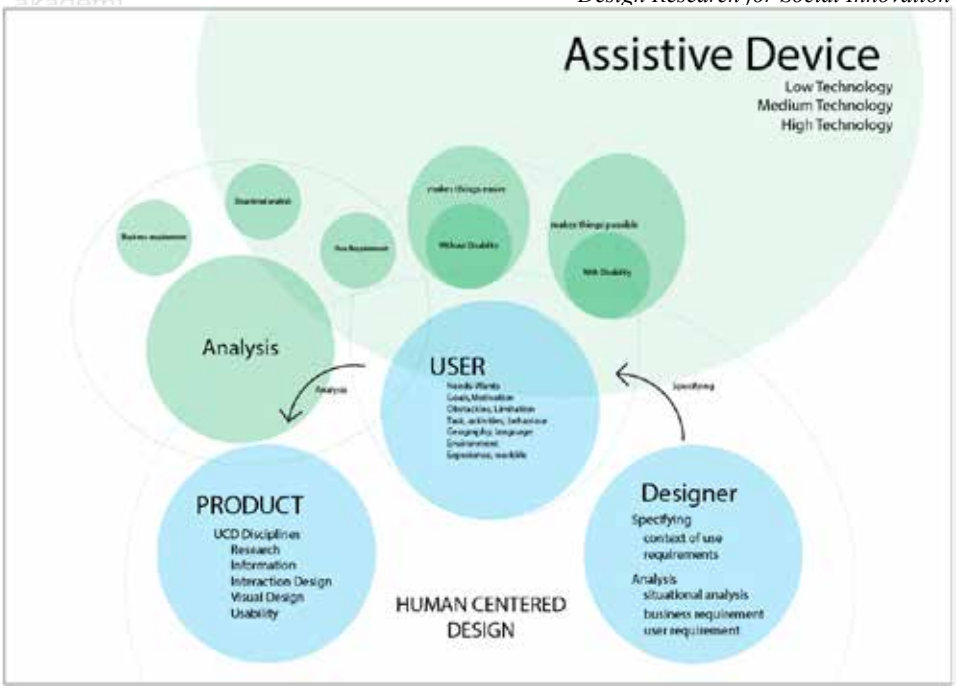

Figure 2. Research concepts and relationship

The action research method used for critical thinking and creating new ideas. To present systematic data by preparing the environment for various collaborations and research (Bogdan, 2012:234-236). The basis of action research is to identify the cause of problems in on real-life experiences. It enables finding solutions to the problems as a result of systematic and relevant work performed with the beneficiaries (Cohen, Manion and Morrison, 2007:307). It is a research method used to improve the quality of education and learning, as well as to understand and improve these learning experiences. The action research method, which provides a successful systematic approach for research processes and implementation processes, was determined as the research method of the study with 4 main steps shown in Figure 3, were applied to the thesis study (Whitehead, 1985:97).

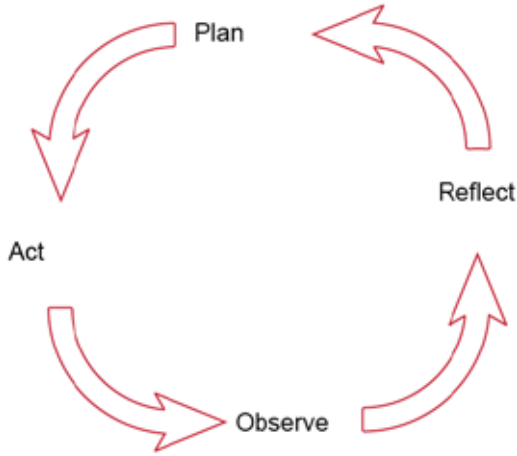

Figure 3. Action Research Cycle (Whitehead, 1985:97-106)

After the research on the topic, a problem definition was determined. Then, depending on the definition of the problem, the process was designed (plan). Research and interview planning was made depending on the established process, and the HAAT model was applied to develop an assistive product proposal within the framework of this plan. Interviews were held with 30 hearing impaired individuals and 20 hearing impaired teachers (act). Analysis and evaluation of the findings obtained as a result of the researches and interviews were made (observe). As a result of synthesizing the analyses, a new product design process and methodology have been designed and a new assistive product design proposal has been developed that can be used in speech and language training of hearing impaired individuals (reflect). It is not enough to have only the design process in the background of a new assistive product development and design process. Individuals who are beneficiaries of products or technologies, participant groups, defining an action or need to be performed should be the starting point of the process. The products and technologies that emerge at the end of the design processes, in which end users or beneficiaries are mostly seen as a part of the processes, define the needs clearly. However, it is often not enough to simply oversee and involve the user and action elements. In the assistive product design process, considering other contexts in the HAAT model, which allows us to define the individual and operational characteristics of the disabled, can increase the accessibility and reliability of assistive products. CanAssist, is one of the best practitioners of this model and the design processes which was created at Victoria University in Canada. This program aimed to develop ancillary product design and service to increase the

disabled individuals' quality of life. With the HAAT model adopted and implemented by the program, data is collected by seeking answers to questions in order to understand the needs of individuals:

1-What is the basis of the intended action and experience?

2- What are the potential uses of the product? (Home, work, school, etc.)

3- At what points will it provide support to individuals?

4-What are the other assistive products in this field? (Silvers, 2010:44)

The products and technologies emerge as a result of the processes implemented by considering these points (Cook, Polgar, and Encarnação, 2020:64-65). The HAAT model is a suitable assistive product technology selection and design process model, which activity, human, assistive product, and context elements are examined throughout the process. This model can be defined as "an individual performing an action using assistive technology in a context", shown in Figure 4. In this study, our goal was to plan and carry out an assistive product design process suitable for learning and speaking education for a hearing impaired individual shown in Figure 4.

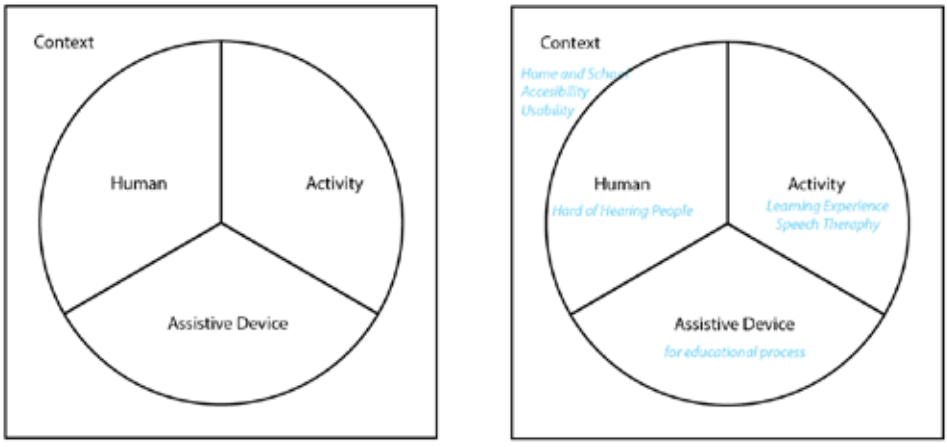

Figure 4. HAAT Model elements' relationships and construction (Cook, Polgar, and Encarnação, 2020:64).

As a result of these systematic approaches, the process designed by using research methods and information resources have been turned into a design methodology and the following process was followed in Figure5.

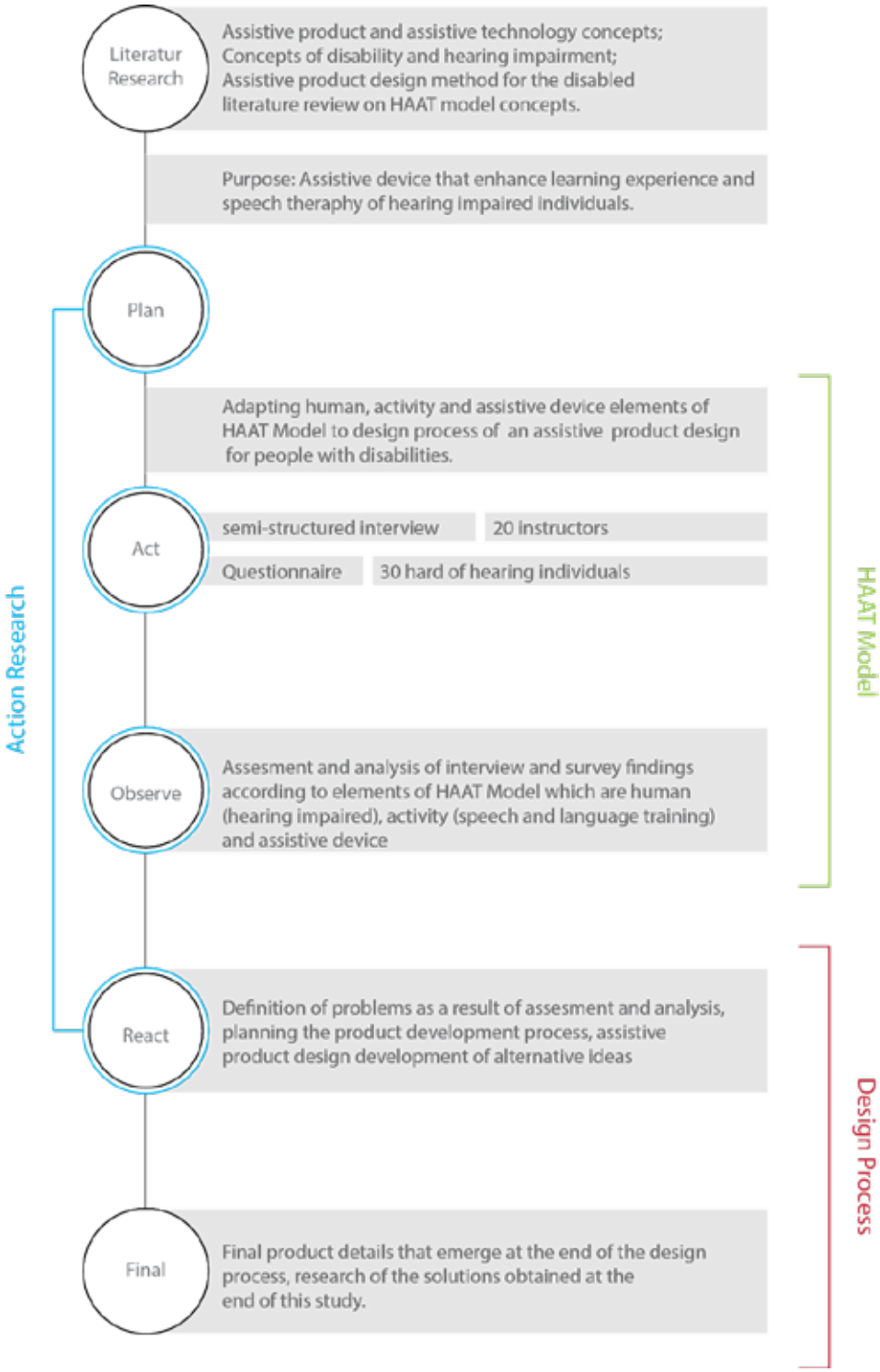

Figure 5. Flow chart of the methodology and process

2.1 Field Research

Within the scope of the study, field research was carried out with an instructor. The main purpose of the studies is to observe the experience of trainers, family members and students in the educational process and to obtain information about the physical and cognitive characteristics of hearing-impaired individuals. During the study, semi-structured interviews with twenty instructors and a questionnaire study were conducted with thirty hearing-impaired individuals.

2.1.1. Semi-Structured Interview with Instructor

The interviews were carried out within the scope of the activity element of the HAAT model. Since the instructors who provide speech theraphy and language education are experienced in the past and current education processes, they can best observe the deficiencies in the curriculum and technical problems experienced in educational process. For this reason, 20 instructors were interviewed in order to examine the problems. During the interviews, the goal was to obtain information about the following subjects:

1- Opinions of speech and language therapists of individuals with hearing loss about the development processes of the individuals.2-The methods used for speech and language education for the hearing impaired,.

3- Positive and negative evaluations of the methods used for the hearing impaired individuals,.

4-The effect of factors controlled by the instructor or not controlled by the instructors during speech and language education.

Interview form had seventeen questions. As a result of all interviews, the findings for each participant were separated and analyzed according to determined following 7 conceptual topics;

1- Experiences of trainers and therapists for impaired groups,

2- Instructor feedback about the duration and proficiency of speech and language education,

3-The methods used to train hearing impaired individuals,

4- The curriculum and functioning of the speech and language education,

5- An example of a basic learning process in language education,

6- Extracurricular education and activity expectations of trainers in educating hearing-impaired individuals,

7- Comparison of the effects of family, instructor and individual on speech and language education of hearing-impaired individuals.

2.1.2. Questionnaire with Individuals with Hearing Loss

The product to be designed with the HAAT Model will contribute to the learning and speech processes of hearing-impaired individuals. Therefore, it was decided to observe the views, expectations and behaviors of individuals within the scope of the human element, which is one of the most important elements of the HAAT Model. For the human element of the model, a questionnaire study was conducted with 30 hard-of-hearing individuals.

In this framework, the goal was to comprehend the importance of speech and language concepts, determine the needs of hearing-impaired individuals in basic learning processes, understand the problems and their sources. In this research the following data was obtained:

1-Academic development and educational background,

2-Learning processes with instructors and therapists,

3-Learning processes with family members,

4-Self-contributions of hearing-impaired individuals to their individual development.

There are 16 questions in the questionnaire thatwas prepared with closed-ended multiple-choice questions in order for the students to express themselves better. With these questions, we/researchers determined the academic levels of the hard-of-hearing individuals, the special education and rehabilitation center experiences, the learning processes with their family members and the issues that will affect their individual learning performance.

2.1.3. Expectations and Opinions of Individuals with Hearing Loss

At the end of the questionnaire session, an open-ended response part was added for students who wanted to express their expectations and opinions. In this part, students were allowed to express themselves in their own sentences. It was provided to examine closely how students used their language and grammar skills and how they expressed their emotions in their own sentences. This part of the study was one of the most clearly understood parts of the difficulties and problems experienced by individuals.

3. FINDINGS, ASSESSMENT AND DESIGN

Most assistive products and technologies that were designed for individuals with hearing loss usually for making their life easy. When the educational, social and professional lives of people with disabilities are observed, it has been observed that the most important point should overcome the problem of hearing-impaired people's language, learning experience and there is no product designed for this aspect. Hearing aids and cochlear implants surgeries improve the hearing ability of people with hearing impairment (Northern ve Downs, 1984:269). How-

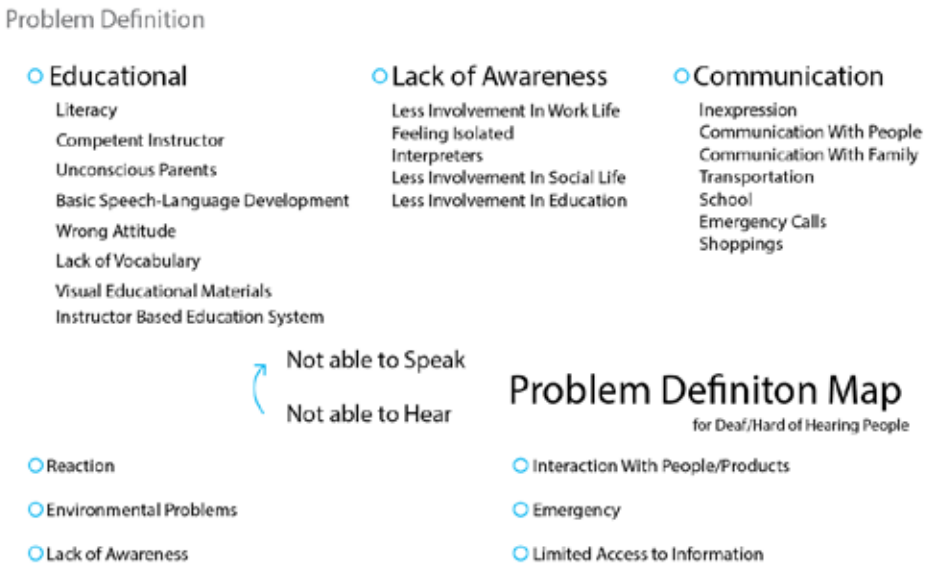

Figure 6. Problem definition map

ever, it is understood that if the special education they need is not provided, it can be difficult for learning and language development to be at a sufficient level in learning and language development.

The design process was evaluated according to the basic elements of HAAT Model human activity, context, and assistive technology. The findings obtained from the literature researches, field studies, questionnaires were evaluated by classifying them according to the mentioned elements. As a result of the evaluations, a problem definition map is shown in Figure 6 was created and a design process was constructed then the process analyzes were converted into design criteria.

3.1. Determining Criteria for Design with Assessments

By assessing the mentioned researches and findings, different design criteria are determined by evaluating the concerns of the different stakeholders of the assistive products planned to be designed for hearing impaired individuals. The criteria were obtained from 3 main analysis.

3.1.1. Education Process Criteria Determined by Instructor Interviews

The assitive product should include the correct methods that the instructors want to apply in the learning processes of the hearing impaired. In addition, it was stated that the processes of evaluating and controlling the extracurricular performance of the students were also important factors for their education. The teaching methods of sound, speech and hearing should be followed in an efficient language education aimed to be applied. Also a method should be developed in which the trainers can evaluate the students easily and efficiently.

3.1.2. Independent Learning Criteria Determined by Student Interviews

While determining the student criteria, the psychological, social, educational and professional lives of the hearing impaired individuals should be taken into consideration. It was observed that students generally spend spent their learning processes dependent depending on others. It is not efficient for them to practice language independently because most of the time there would be no one to give feedback.

3.1.3. Education Method Criteria Determined by Current Education Methods

The traditional education and training methods applied for hearing-impaired individuals may not be sufficient for individuals. The methods to enable students to focus on different fields are also lacking (learning different languages, music education, etc.) For this reason, the education of hearing impaired individuals in different fields has been determined as a criterion.

It was also observed that the efficiency of basic voice training given to the students, was not at the desired level. Basic language and articulation training should be provided efficiently. Also, considering most hearing-impaired students receives receive special education, the product that students will use is expected to be suitable for the individual, instructor-led and group training.

3.1.4. Criteria Determined by Current Technologies and Researches

For these criteria, both products and technologies used by hearing impaired individuals and other assistive products were examined. When disabled individuals were evaluated socially and psychologically, they often feel felt withdrawn,incomplete and excluded. The products should help individuals to overcome these disadvantages.

Some of the new criteria derived from current research-which were determined during the Vitalk (2016) project and confirmed by the findings obtained within the scope of this study. The criteria, that would affect the design was shaped by analysis, limitations, goals and orientations gathered in Table 1.

Audio-Visiual Feedback	Audio-Visiual Recognition	Upgradable Improvable	Easy to Understand	Esthetic Proper Material
Mobil	Wearable	Compact	Flexible Use	Scenario Variety
Standard Component Current Technology	Medical suitability	Encourage to Different Field	Efficient Learning Education	Current Esthetic
Feeling of Voice psychological criteria	Following of process/development	Easy to Use	Easy to evaluate	Articulation and Voice Education

3.2. Solution Process for Learning Experience

The product proposal is basically based on the basic learning experience and basic sound formation. Also, describing where individual made mistakes while creating sound and how to fix these mistakes are being main function of the product. While creating sound, the goal was to take the visual and auditory inputs from the user and process then evaluate them according to the sound that the individual will make. As a result, it is aimed to give feedback to the individual according to this evaluation.

Sophisticated feedbacks allow individuals to see the mistakes faster and learn faster. It is expected that the individual will be encouraged with the feedbacks until they make the right sound. In addition, it was determined that the evaluation and follow-up of student development throughout the education process should be possible. The common process of individual, group work and language training with an instructor is presented in Figure 7.

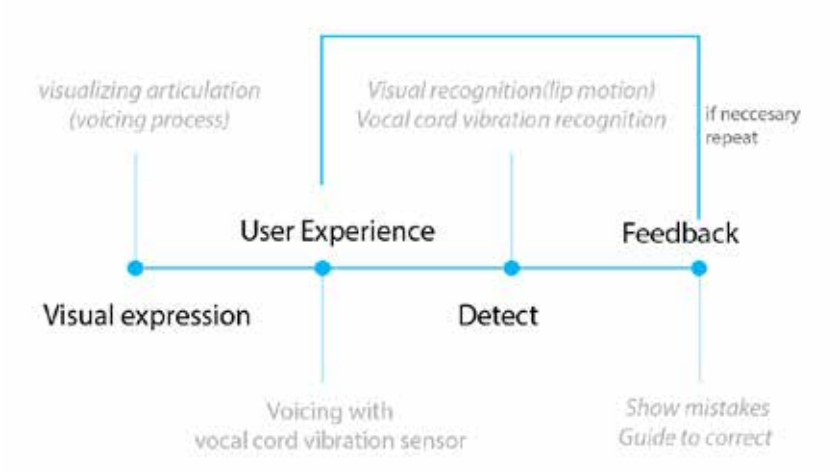

Figure 7. Solution Process for Learning Experience

3.3. Final Product

Even if the physical characteristics of individuals change, every person has a similar sound production process for the same sounds. Therefore, it is a goal to detect the inputs in this sound production process and to give feedback to the user for the make sound. The product consists of a screen and sensors that detect vocal cord vibrations as seen in Figure 8. When users create a sound, they bring

the sensors closer to their vocal cords. Kinect Camera enables individuals to make correct lip and face position. The screen software shows the changes. In this way, the users see which sound they should make and how successful they are. The vibrations and process are matched with the frequency values of the correct sound in an algorithm in the product. The progress can be followed until the user makes a sound with a value close to 100% correction. In addition, these values are recorded so that the instructors can evaluate and follow their student.

Figure 8. Final Product

It is aimed to design a user-friendly interface that allows instructors, family members and students to realize all experiences. The use and access of the interface were provided for all three groups and their authorizations were determined. An example scenario is shown in Figure 9 for a sound training is described below.

In first screen individuals select the fundamental mode. Individual mode is used for studying or practising alone, instructor and group mode is for training with someone. In second screen, hearing-impaired person have a chance to many types of upgradable courses and levels for continued training. In third screen, different basic and advance context can be used by individuals to improve themselves independently. From basic to advance courses, it also shows last match of vocal cord vibration to checking easily on the fourth screen. When select for example S sound for practicing, individuals experience visually animated sounds give people the chance to understand how to make correct sound. Then it is a turn to experience. When individual try to make sounds, there are visual feedbacks, and these feedbacks is give chance to feel their Voices. Then inputs match with correct vocal cord vibration and correct lip motion. In sixth screen, Feedbacks and directives enable to understand how to make correct sound and encourage people to practise more.

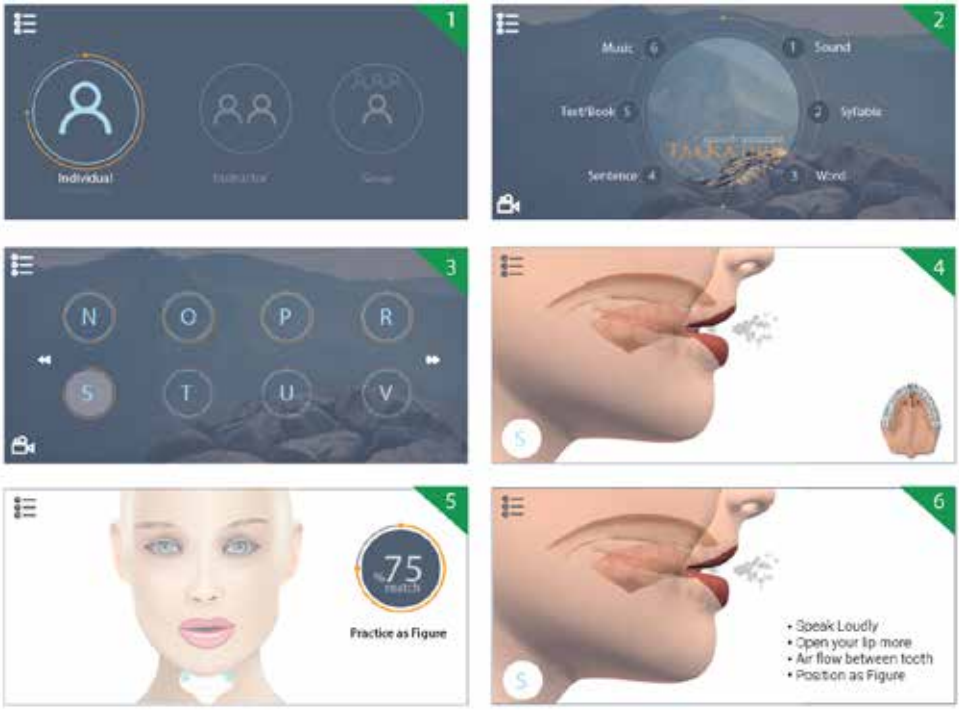

Figure 9. User interface and scenario

4. CONCLUSION

In this research, the design methodology which was based on the conceptual assistive device project for hearing-impaired people as a case study was seen as applicable to assistive product design processes for people with disabilities in terms of process setup. The applied design methodology is structured on the action research methodology and the HAAT model. The reason for using design methodology for assistive device design is to determine all factors that affect the product and the experience of disabled user groups. In addition, it provides easier access to systematic analysis that will construct solution advances on this experience and factors in this way. Making this systematic approach a design methodology by constructing it with research methods and information resources is the most important output of this study which is shown in Figure 5. The structured methodology is based on observing the education processes, individual expectations, and needs of hearing-impaired people, providing sufficient findings for a solution, determining the items to be researched with the HAAT Model, and examining different research methods.

As a result of the systematic approach, the idea of a product group with a sensor that detects vocal cord vibration, and a Kinect sensor with a display unit was decided. An educational process proposal consisting of sounds, syllables, words, sentences, texts, and books has been could be designed for disabled people. Thus, to teach any sound to a hearing-impaired individual, how the sound is formed is visualized firstly. For the conceptual assistive device, it is envisaged envisioned to provide audio data with a microphone, visual with image processing Kinect sensors, and vibrational data with a vocal cord vibration sensor. It is planned to understand whether the disabled individual could make the sound correctly by processing the data. If not, the information about which deficiencies have effects to correct sounds should be provided with visual and auditory feedback. Hence, the product that visualizes the process will provide feedback to the individual in every aspect, to allow people with disabilities to feel their voices more. Hardware and software alternatives are specified for the solution. The alternatives in point were detailed by considering their technological infrastructure, and the final evaluation process was started by determining the research questions and findings for the final design proposal that could offer the most efficient solution to the problems of disabled people After the findings were evaluated, the final design decisions were taken by improving the details of the current Vitalk (2016) design by the way of the product and user experiences that were reconsidered in the process.

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