The development of assistive technology product concepts using design thinking

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ABSTRACT

This work presents the proposal of a reference model for research projects for the development of assistive technology (AT) product concepts for the air transport sector based on a design thinking approach. The proposed model is a result of the evaluation of a set of research projects conducted by teams of researchers and undergraduate students. Based on information acquired from a literature review and the analysis of these projects, a set of specific characteristics and requirements were determined with the further objective of creating a reference model for the development of assistive technology product concepts based on a design thinking approach. The model could be used by other research groups and other universities, and could later be expanded to the industry.

INTRODUCTION

The ongoing population growth and population aging will demand new assistive technology solutions in the near future. At the same time, the worldwide growth of the air transport sector presents specific challenges for the development of assistive technologies (AT) as accessibility needs to increase in the air transport sector [1].

In an attempt to address these issues, the two projects analyzed in this paper focused on the development of AT solutions for people with disabilities and passengers with reduced mobility to improve passenger's mobility during the air travel experience. The projects were conducted according to a design thinking approach, and the results are compiled together with literature findings to provide input for the creation of a reference model for the development of conceptual assistive technology products based on design thinking approach.

Design thinking (DT) has been popular in the last decade due to successful cases of application in big companies [2]. DT has been applied as a response to the increasing complexity of businesses and recent technologies in an attempt to allow interactions of people with technologies and services to be simple, intuitive and pleasurable. One of the main aspects of DT, together with prototyping iterations and multidisciplinary teams, is its user-centered design, which translates into building empathy with users and focusing on their experiences. Using this approach helps the team to better understand what users want and need [3]. DT also allows the team for a rapid immersion into the problem, facilitates the generation of new concepts and enables them to come up with unconventional solutions and contributes to the creation of solutions with better market fit [3,4].

The design thinking approach proposed at Stanford University has been extensively explored and tested in several research projects at the Stanford ME310 course, which is held yearly and involves groups of local students and students from foreign universities working together on a design challenge proposed by a partner company [5]. One of the DT proposals considers six project phases which starts with a need finding and a benchmarking for the immersion into the problem space. Next, a sequence of five ideation-prototyping-testing cycles starts. The scope of the problem is narrowed, the solution is improved through the prototyping cycles and a final prototype is built in the last phase [5].

Coming up with a successful product is not easy, but replicating the success in other projects is even harder [6]. Considering that, processes used in projects of product development can be modeled and become a reference for best practices, and can also shorten innovation lead-times and reduce costs [7,8]. Models such as the Stage-Gate®, created by Robert Cooper in the 1980's, have been successfully applied in several industries in the last decades [9]. So, it seems reasonable to establish a specific model to use the design thinking approach in other projects. Regarding the product development process (PDP), there are several industry-specific process reference models [10]. These models cover the pre-development, the development and the post-development phases of the process. The pre-development corresponds to the initial ideas and planning of the project. The development phase consists of informational project and conceptual project, followed by the detailed design and production process until the launch to market. The last phase includes the stages of production maintenance and product discontinuity [7]. For this study, the scope of the model is restricted to a part of the entire PDP, strictly from the project planning until the conceptual project, since the projects of the case studies were only research projects and their results had not reached the production stage neither the market yet.

During the literature review, no reference model based on design thinking was found for the development of AT for the aeronautics industry, but some research related the development of AT products was found. The Need to Knowledge (NtK) Model proposed by the Center of Assistive Technology of the University of Buffalo in NY focuses on the transition of outcomes of a research project into the market [11]. Cook and Hussey's HAAT model (Human Activity Assistive Technology) considers the characteristics of an AT solution from three aspects: human, technological and contexts (social, cultural) [12].

The aim of this present work is the proposal of a reference model for the development of AT product concepts based on a DT approach for the aeronautics industry. To determine specific characteristics and requirements, authors used a literature review and analyzed a set of projects conducted for the development of AT which focused on solutions for assisting passengers with disabilities or reduced mobility in the air transport sector.

METHODS

The method applied in this study consists of two case studies, which are analyzed and have the results compiled with information from a literature review. After the compilation, a set of main characteristics is established to support the creation of a reference model for the development of AT product concepts specific for the air transportation to be used in research projects.

The projects were conducted by teams of researchers, graduate students, and undergraduate students within an assistive technology research group in a university. The first project was concluded in 2013 and 2014 by a group of seven students as part of Stanford's ME310 course. Sponsored by an aircraft manufacturer, the group included four students from Stanford University and four from a foreign university, from design, mechanical, computer and production engineering courses. The initial problem was redesigning the flying experience for passengers with reduced mobility. The final result was a solution for safer transportation of the passenger's wheelchair and a new wheelchair for an easier embarking and transfer to the passenger's seat inside the aircraft [5]. The analysis of the project was based on project documentation and interviews with the team members.

The second project, financed by a governmental grant and concluded in 2016, also included a team of undergraduate students and researchers. It focused on the development of an improved model of wheelchair that facilitates the embarking and disembarking of passengers with disabilities or reduced mobility. The persona chosen for the project was a passenger with paraplegia or reduced mobility in the lower limbs. The result was a concept for a more comfortable wheelchair that included some features to facilitate the passenger's transit and a lateral seat movement for the transfer to the aircraft seat [13]. The authors participated as project managers.

RESULTS

CHARACTERISTICS RELATED TO AT PRODUCTS	ORIGIN		MODEL FEATURES
Diversity of conditions and individual characteristics for each disability and for each patient	Literature / Projects	⇨	Multidisciplinary team, Involvement of Health professionals, User-centered design (Design Thinking), Universal design
Variations of conditions among people with the same disabilities	Literature / Projects	⇨	Multidisciplinary team, Involvement of Health professionals, User-centered design (Design Thinking), Universal design
Low production scale	Literature	⇨	Rapid prototyping
Signs of applicability of DT to the development of AT products	Literature / Projects	⇨	Design Thinking approach
Need of a thorough understanding of users' needs and requirements	Literature / Projects	⇨	User-centered design (Design Thinking)
User participation during the initial stages of the project	Literature / Projects	⇨	User-centered design (Design Thinking), Contact with users in the beginning of the project
User participation during tests and evaluations	Literature / Projects	⇨	User-centered design (Design Thinking), Involvement of users during tests and evaluations
Empathy of the team for the users and the solution	Projects	⇨	User-centered design (Design Thinking)
Multidisciplinary teams	Projects	⇨	Design Thinking approach, Multidisciplinary teams
Series of prototyping cycles allows for fast failure and improved final solutions	Literature / Projects	⇨	Design Thinking approach, Various cyles of prototyping
Rapid prototyping provides agility and makes customization easier for AT products	Literature / Projects	⇨	Rapid prototyping
Norms ans regulations dependency	Literature / Projects	⇨	Consideration of norms and regulations
Air transport sector dependency on international norms and regulations, Governmental agencies and aviation entities	Literature / Projects	⇨	Consideration of norms and regulations

Figure 1. Translation of characteristics related to AT products into model features

As a result, a list of characteristics related to the development of AT products is compiled with information acquired from the literature review combined with the analyses of the two projects. These characteristics are translated into features that led to the proposal of the reference model (Figure 1). Among these features are multidisciplinary teams, involvement of users in activities throughout the project, universal design considerations, user-centric design, and prototyping cycles.

The proposed model illustrated in Figure 2 consists of three project phases. The first is dedicated to the understanding of the users' needs and requirements and is divided into three stages. The second phase is dedicated to the development of the product concepts. It starts with the Critical Function Prototype (CFP), which explores the basic functionalities desired for the solutions. After that, the Dark Horse stage is meant to explore alternative and innovative ideas assumed to have lower chances of success. After the solutions are chosen, the following two stages are dedicated to exploring and detailing the functionalities that should be part of the final solution. In the *Funktional* stage, the team should explore how the functionality should be constructed, and then use the Functional stage to experiment and improve the chosen functionalities. In all these stages the team should work on prototyping cycles, which includes an ideation or brainstorming section, then prototyping and testing. The third phase is meant for the construction of the final prototype.

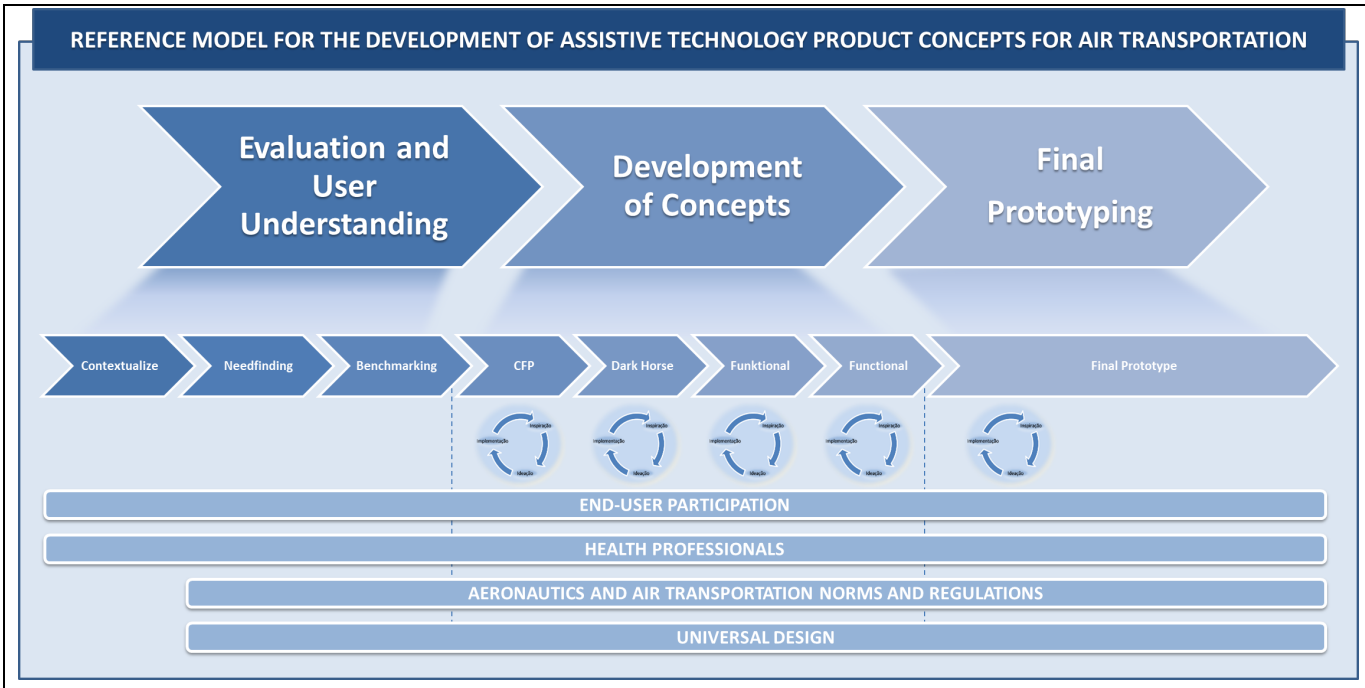

Figure 2. Reference model phases and activities with prototyping cycles and other features

Specific characteristics are also distributed across the phases and their stages. The participation of the end-user should be present since the first stages of the project, as part of the user-centric approach of the design thinking. The involvement of health professionals, especially those who have direct contact with the user, should also be taken into consideration, as they can add valuable information about both their and the user's needs and requirements, as well as some specificities of their regular routines. Moreover, the design of the solution must take into account specific norms and regulations for the product sector.

DISCUSSION

In order to explore the applications and possibilities of design thinking, the two projects adopted a DT approach to develop AT solutions for people with disabilities. The projects were conducted by teams of researchers and undergraduate students and resulted in the development of new concepts for a wheelchair. Considering that the initial problem included an open scope with the specific solution being developed along the project, the DT approach showed good results with innovative ideas to solve known issues [4,5,14].

The results of the application of design thinking tend to add more value to the final user as their needs and requirements are explored and considered into the design since the beginning of the project. Therefore, their needs and requirements can be considered into the development of the final solutions since the first stages. This information can be collected from the interaction with the users as well as with the health professionals who work directly with them.

Including design thinking into the model encourages the development of innovative ideas, the generation of new concepts and unconventional solutions. Mainly due to its user-center characteristic, DT seems to be suitable for the development of AT solutions, and the prototyping cycles help to solve design issues earlier in the project.

CONCLUSIONS

Together with a literature review, two projects for the development of AT solutions for the air transport sector were analyzed. A compilation of characteristics was made considering those identified in the literature and also in the researched projects. Based on this list of characteristics, a set of specific characteristics for a reference model was inferred. Finally, considering the experience involved in the analyzed projects and the final set of characteristics, a reference model is proposed for the development of concepts of assistive technology products for the air transport sector using the design thinking approach in research projects. Initially, the proposal is intended for use in research projects only, since it does not cover the additional steps of the PDP model to production process development.

For future research, these results could be used by other research groups and institutions for gathering data from new case studies. The reference model can be used by other research groups and institutions for structuring their projects or to begin applying the design thinking approach for development of new AT solutions for the air transport sector. It could also be used for the development of regular AT solutions outside the specific air transport sector, and further expanded to the industry as a new approach for conceptual development in the early stages of their PDP.

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