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ICT in Business

Developing assistive technology products for visually impaired people from users' and stakeholders' perspectives

A theoretical framework for engaging users and stakeholders in the innovation process by using co-creation approaches

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"…for a true co-creation process to work effectively the end-user needs to be placed explicitly at the same level of importance as the company."

Bryan Urbick

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Abstract

Objective: To propose an acceptable and generic theoretical framework for involving the end-users and various types of stakeholders relevant for involving in the assistive technology product development process (ATPDP).

Design/methodology: The author proposes a generic theoretical framework which includes different routes, methods/tools and stages through which assistive technology product (ATP) users and various types of relevant stakeholders can be involved in the ATPDP.

Findings: Co-creation is a very suitable approach for engaging visually impaired people in the innovation process. Therefore, a co-creation approach has been incorporated in the proposed conceptual framework. Furthermore, the framework addresses multiple routes for engaging users' and stakeholders' in ATP development including end-users' route, non-professional stakeholders' route, professional stakeholders' route and a combinations of routes starting from concept development through to the market deployment. In addition four scenarios of ATP development is provided to illustrate the application of this framework.

Research limitations: Several different research directions could provide additional useful information. The main research opportunity exists in implementing and/or testing the proposed framework in real life projects to measure its effectiveness.

Originality/value: The theoretical contribution is: (1) the author identifies the various types of stakeholders (professionals as well as non-professionals) in the development process of ATPs for visually impaired people, (2) identifies how and in what stages of the innovation process the users and these stakeholders can be involved, (3) proposes a conceptual framework for co-creation of ATPs. The managerial contribution is providing ATP developers with a tool to make decisions about how and in what stages of the development process these stakeholders and end-users can be involved.

Keywords: User engagement, stakeholders' engagement, assistive technology product development, assistive technology product assessment, user and stakeholders perspectives, conceptual framework, participatory design, co-creation.

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Chapter 1: Introduction

User involvement in the early stages of new product development is very important (Marc Steen, 2007), (Bhuiyan, 2011). When we look at development and evaluation of medical devices, we see a similar situation (Syed Ghulam Sarwar Shah I. R., 2007), (Syed Ghulam Sarwar Shah I. R., 2009), (Jennifer L Martin, 2006), (Robinson, 2006), (Arthur G Money, 2011) and when developing specific products for specific types of users. In this case the development and evaluation of assistive technology products (ATPs) (Andrew I® Batavia & Guy S. Hammer, 2010), (Fernandes, 2010), (Ruth E Mayagoitia), (Clarke, 2011). In addition evidence shows that stakeholders' engagement is also very important in the process of new product development (Sinclair), (Katharine Partridge, 2005), (Thomas Krick, 2005), (Morris, 2012), (Jeffery, 2009), (Savitz's). Therefore, we can state that not only users' involvement in ATP development is important and useful but also involving various types of stakeholders' can be as much important and useful as the end-users. In ATP development, user involvement can provide a number of advantages, including access to user needs, user experiences with ATPs, new ideas about ATPs and suggestions on potential improvements in assistive technology product design (ATPD) and the creation of better user interfaces. Furthermore, involving the end-users in the ATPDP can lead to ATPs with improved functionality, usability, safety and quality. In addition, user involvement at early stages of the innovation process helps in identifying potential problems in the ATP. This reduces the need for costly modifications (Syed Ghulam Sarwar Shah I. R., 2009). On the other hand involving the stakeholders in the assistive technology product development process has also some advantages, including access to user needs because, these stakeholders are in some ways in touch/have a relationship with the end-users. Therefore, we believe the stakeholders can easily observe/capture the user needs/requirements. Furthermore, like the users the stakeholders also can come up with new ideas e.g. they may have suggestions regarding potential improvements in the ATP or user interfaces. A stakeholder in the ATP development process can be for instance family members, friends, caregivers' ophthalmologists etc. More information about the

various types of stakeholders relevant for involving in the ATPDP for visually impaired people i.e. blind and people that have low vision is provided in section 4.3. Furthermore, a definition of visual impairment is provided in section 3.1.

1.1 Problem statement

Prior studies show the under-use and abandonment of assistive devices (Garber S, 1990), (Phillips B, 1993), (Ko M, 1998). It has been suggested that this is due to their lack of compatibility with the users' needs, roles, values and context (Smith, 1995). ATPs are more likely to be used if they enable users to complete important tasks and facilitate social and psychological freedom rather than just physical functioning (Phillips B, 1993). Therefore, we suggest that the end-users should be given the opportunity to share their ideas in ATP development and should get engaged in the innovation process. In this study, we explore how users and the various types of stakeholders can get engaged in the innovation process of ATP development for visually impaired people. More information about the innovation process of developing ATPs is provided in section 4.1.

Although we know the users which are in this case the blind and partially sighted people, a critical issue may be the identification and selection of the various types of stakeholders, the methods/tools for involving these users and stakeholders, and in what stages of the ATPDP these users and the various types of stakeholders can be involved. This raises a number of questions including, who are the relevant stakeholders in the ATPDP. Literature review shows that there are several stages in the innovation process and several methods/tools for involving the users and stakeholders are available e.g. conventional approaches which we discuss in section 4.4 and new collaborative approaches which we discuss in section 4.6. A major challenge is identifying and using the methods/tools that are most appropriate in the different stages of ATPDP. All these issues are critical in planning and undertaking a meaningful users and stakeholders involvement initiative. According to Andre TS, user involvement depends and/or is facilitated by the availability of an appropriate framework (Andre TS, 2001).

Literature has been reviewed and there is no universal and formal framework for the involvement of both the end-users and the various types of stakeholders in the ATPDP for visually impaired people from conceptualization through to the market deployment by using new collaborative approaches i.e. the co-creation approach reported. Some of the limited available frameworks describe for instance only users' involvement and nothing is mentioned about stakeholders' involvement or they describe users' involvement with the use of conventional approaches. More information about conventional approaches is provided in section 4.4. In contrast we are interested in the use of the co-creation approach for users and stakeholders involvement because, we believe the co-creation approach is more appropriate for engaging special types of users and the various types of stakeholders at the same time in the innovation process of ATP development. More information regarding the co-creation approach is provided in section 4.6. The most relevant framework that was available in the literature to solve the above mentioned problems in the development process of medical devices has been introduced in 2009 (Syed Ghulam Sarwar Shah I. R., 2009). Although an ATP is considered as a form of a medical device (Syed Ghulam Sarwar Shah I. R., 2009), (Hersh, 2010) and perhaps the available framework can be used to solve some of the above mentioned problems, we believe a new framework incorporating the co-creation approach which can support co-creation activities and direct involvement of the end-users and relevant stakeholders in the ATPDP needs to be developed. In the context of ATP development, we believe the available framework does not provide the solution which can be applied to solve issues regarding ATP development mentioned in this section. This is because in that framework not the stakeholders related to ATP development are identified. In that framework which is developed for involving different types of users in medical device development, the authors use the term professional users instead of stakeholders. They argue that a medical device may be used by the end-users as well as the professional users. Although an ATP is considered as a form of a medical device, in this case an ATP is developed for the end-user and will be used by the end-user. The stakeholders are not going to use it. Therefore, the stakeholders should not be classified as (professional) users. They need to be separated into two groups i.e. the end-users and the stakeholders. Moreover, we believe that the stakeholders

also need to be separated into two categories including the professional as well as non-professional stakeholders. More information regarding the two types of stakeholders relevant for involving in the ATPDP is provided in section 4.3. Furthermore, the available framework addresses three scenarios in the development process of medical devices including;

- development of a medical device new to the market,
- major upgrade of an existing medical device,
- redesign of a medical device prototype.

Figure 1: Google Glass[1]

We believe a fourth scenario should be added to the new framework which describes transforming mainstream technology into an ATP e.g. recently Google has introduced their wearable computing device[2] Google Glass as shown in Figure 1. Originally this gadget has the purpose to be used as an entertainment gadget. We believe this device can be transformed into an ATP by modifying the hardware and/or developing specific software that will run on the gadget which then can function as an ATP for visually impaired people. More information about different scenarios in ATP development is provided in section 6.5. Furthermore, the developments in the gaming industry can also inspire developers to use game technology in developing ATPs. For instance the Wii Balance board which is originally

[1] Image source: http://www.apparata.nl/image-gallery?file=Google/Glass/google-glass-001.jpg
[2] A term that refers to computer-powered devices or equipment that can be worn by a user, including clothing, watches, glasses, shoes and similar items, information retrieved from: http://www.webopedia.com/TERM/W/wearable_computing.html.

developed as game controller for regular gamers. This controller can also function as an aid for blind people when playing games. More information about how the Balance board is used as a game controller by blind children is provided in Chapter 5. And presumably there are many other technologies available that could be transformed into an ATP. Therefore, the fourth scenario is a relevant/essential addition to the new framework. In order to solve the issues related to ATP development discussed in this section, we believe there is a need for an acceptable and generic framework for involving the end-users and the various types of stakeholders in the ATPDP for visually impaired people.

1.2 Research objective

Based on our findings in literature, case study and informal interviews we try to establish a theory and develop a conceptual framework that can be used by ATP developers to make decisions about in what stage and how the end-users and the various types of stakeholders relevant in ATP development for visually impaired people can be involved in the innovation and evaluation process.

1.3 Research question

In this study the following research question will be answered:

"*How can users and the various types of stakeholders get engaged in the innovation process of developing assistive technology products for visually impaired people?"*

This research question will be answered with the support of the following sub-questions.

Sub-question 1: What forms/types of co-creation are currently known in the literature?

To answer this sub-question literature related to this topic is reviewed to identify the various forms/types of co-creation.

Sub-question 2: What methods/tools can be used to support co-creation activities in the different stages of ATP development?

To answer this sub-question literature related to this topic is reviewed to identify methods/tools supporting co-creation activities that are relevant in ATP development for visually impaired people. In addition we also look at methods such as living labs and social media which can be used for collaboration in projects. Presumably living labs and social media can be used as a co-creation method/tool.

Sub-question 3: What stages in the innovation process are relevant for users' and stakeholders' engagement when developing ATPs for visually impaired people?

To answer this sub-question literature related to this topic is reviewed. This sub-question is used to explain the different relevant stages for users and stakeholders' engagement in the innovation process of developing ATPs for visually impaired people.

Sub-question 4: What stakeholders can be involved in the innovation process of developing ATPs for visually impaired people?

To answer this sub-question literature related to this topic is reviewed and information is retrieved from different organizations that provide services for visually impaired people. This sub-question is used to identify the different stakeholders that can be involved in the innovation process.

Sub-question 5: To what extent is co-creation a suitable approach for engaging special types of users i.e. visually impaired people in the innovation process?

To answer this sub-question literature related to this topic is reviewed and a single case study is done to identify the results of engaging visually impaired people in the innovation process.

1.4 Scope

In this study we explore how visually impaired people and the different stakeholders can get engaged in the ATPDP. Thereby we specifically explore to what

extent co-creation is a suitable approach for involving special types of users, in this case visually impaired people in the innovation process. We incorporate the co-creation approach in the proposed conceptual framework. In the framework, we suggest generic methods/tools that can support co-creation activities in the different stages of ATP development. One of the predefined boundaries in this study is that we do not define/suggest methods/tools that are not available in the literature because, we only want to suggest methods/tools that have already proven its success in other projects (increase validity). The second predefined boundary is that we rely on literature to identify the different stages relevant for involving the users and the different stakeholders in the ATPDP for visually impaired people. The third predefined boundary is that we do a single case study to explore the results of using the co-creation approach in the innovation process of developing products for these special types of users because of time constraints. Furthermore, to get feedback and evaluate the proposed conceptual framework, professionals at different organizations that provide services for visually impaired people are interviewed. In addition, we conduct informal interviews with the same professionals mentioned above and we do extensive literature review to identify the various types of stakeholders relevant in ATP development. Another predefined boundary is that we only focus on users' and stakeholders' perspective in the ATPDP, since there are also other perspectives known in literature e.g. regulators' and manufacturers' perspectives. However, these two perspectives are out of the scope of this study.

1.5 Contribution

Evidence shows that user involvement in ATP development is very important as discussed in Chapter 1. The theory shows that the researchers mainly focused on user involvement and less research has been done on stakeholders' involvement in ATP development. In this exploratory study our theoretical contribution is: (1) we develop a conceptual framework for co-creation of ATPs for visually impaired people. (2) in the framework, we identify the various types of stakeholders relevant for involving in ATP development for visually impaired people (professionals as well as non-professionals), (3) we identify how and in what stages of the innovation

process these users and the various types of stakeholders can be involved, (4) we identify different routes that ATP developers can follow when developing ATPs, and (5) we identify different scenarios to illustrate in what situations the proposed framework can be used. Our managerial contribution is to provide ATP developers with a tool to make decisions about how and in what stages of the development process these stakeholders and users can be involved.

1.6 Thesis structure

This document consists of five main parts. In the first part the main research information is provided regarding the research topic. This includes a general introduction to the topic, problem statement, research objective, research question, scope, contribution and the research methodology that has been used in this study. All this information can be found in the Chapters 1 & 2.

The second part provides background information about visual impairment i.e. blindness and low vision, and the challenges that these people experience in daily life and different ATPs that are available for these people. By providing this background information the reader gets an understanding of what visual impairment includes and why ATPs are very important for these people in performing their daily activities. This information can be found in Chapter 3.

The third part provides information about users and stakeholders' engagement, conventional approaches, the co-creation approach for users and stakeholders' involvement, why the co-creation approach can be used in contrast to the conventional approaches to engage end-users and stakeholders in the innovation process. Furthermore, information is provided regarding the case study results of using the co-creation approach for the development of a Wii game for blind children. This information can be found in the Chapters 4 & 5.

In the fourth part we introduce the proposed conceptual framework and we provide the necessary information about what the framework includes to make sure

the reader gets an understanding of the framework. This information includes the different stages of the ATP development process, the possible scenarios and the different routes that can be followed by ATP developers. This information can be found in Chapter 6.

The final part consists of two chapters i.e. discussion and conclusion. In this part we also provide information about what the limitations and implications are of the proposed conceptual framework. Furthermore, some suggestions are made for future research. This information can be found in the Chapters 7 & 8

Chapter 2: Research methodology

In this exploratory study, we primarily rely on secondary data because of time constraints. Information has been collected through extensive literature review including the theories users' involvement in ATP development process, conventional approaches in product design, the co-creation approach and different methods/tools that can support co-creation activities. Furthermore, some primary data has been collected through conducting informal interviews with professionals at Royal Visio[3] and Ergra Low Vision[4] that provide services for visually impaired people. During the interviews we asked these professionals feedback regarding the proposed conceptual framework e.g. what needs to be changed, what can be improved, what stakeholders can be involved, how users and stakeholders can be engaged and in what stage(s) of the development process these users and stakeholders can be involved etc. In addition we also did a single case study to collect information about the results of using the co-creation approach for engaging visually impaired children in the innovation process. The case study includes a project which was performed in 2008 where a Wii game was developed using the co-creation approach. The outcome of this project was positive. Therefore, we decided to explore how this approach can be applied to engage end-users in the ATPDP. More information about the case study findings is provided in Chapter 5. We incorporate a co-creation approach in the proposed conceptual framework. In our theoretical framework we describe what methods/tools in what stages of ATP development can be used to engage the users and the various types of stakeholders.

[3] Royal Visio in the Netherlands provides vision rehabilitation services, supports, encourages and counsels blind and partially sighted people by providing courses, training and other programs. The term "vision rehabilitation" includes a wide range of professional services that can restore functioning after vision loss. Information retrieved from: http://visio.org/home-gb?lang=en-GB

[4] Ergra Low Vision is a specialist in the field of low vision in the Netherlands and Germany. The specialists work closely with ophthalmologists in hospitals, care centers and eye clinics. Their core business is (1) giving advice and measurement of optical devices for home or work, and (2) doing optometric and preventive research in care centers. Information retrieved from: http://www.ikwilbeterzien.nl/over-ergra-low-vision

This exploratory research can be classified as qualitative research. It is a qualitative research because, based on our findings in literature, case study and informal interviewing we try to establish a theory and develop a conceptual framework that can be used by ATP developers to make decisions about how and when to involve the users and the various types of stakeholders in the innovation process. In this study, we use both qualitative data gathering as well as qualitative data analysis (Aken, 2003). For qualitative data analysis the immersion and crystallization approach is used (Miller, 1994). We choose to use the immersion and crystallization approach because, the topic using the co-creation approach for engaging special types of users and the various types of stakeholders in the innovation process is a relative new and complex topic. Therefore, it is required to do an extensive literature review to gain understanding about the subject (immerse in the topic) and then filter and analyze the information that is relevant for this study (crystalize).

2.1 Research strategy: the immersion and crystallization approach

In this section, we provide general information regarding the research approach that has been used during this study. This includes a general description of the immersion and crystallization approach. Our research consists of five phases see Table 1 below. We choose to conduct additional informal interviews in phase five because, we wanted to use the information of the interviews (if necessary) to make changes/to improve the proposed theoretical framework and to involve practical knowledge of professionals in theory building.

Phase	Activity
1.	Standard literature review to read and collect information about the chosen topic.
2.	Extensive literature review regarding users & stakeholders involvement in the innovation process and the co-creation approach.
3.	Case study to identify the results of involving blind and visually

	impaired people in the development of a product for blind and visually impaired people. In addition some people who were involved in the Wii game project have been interviewed to explore what the experiences were of using the co-creation approach in that project.
4.	Development of the conceptual framework.
5.	Informal interviews with the professionals at different organizations that provide services for visually impaired people to evaluate the proposed conceptual framework and improve it if necessary.

Table 1: Phases of the research project

The term immersion and crystallization is used in the analysis process of qualitative research. With the immersion and crystallization approach the researcher starts with as little information as possible and immerses himself into the research topic. In the book "Doing Qualitative Research" the authors have visualized the process of immersion and crystallization (Benjamin F. Crabtree, 1999) as shown in Figure 2 below.

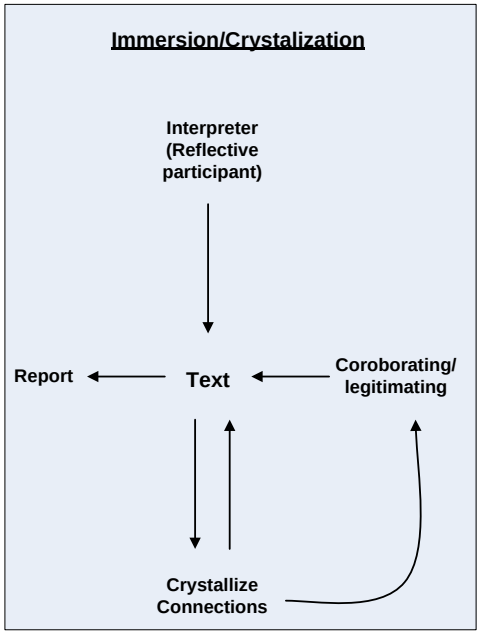

Figure 2: The immersion and crystallization process visualized[5]

[5]This image is used by Benjamin F. Crabtree In his book "Doing Qualitative Research" to visualize the process of immersion and crystallization.

This approach is a so called dual process which continues until all the data has been examined and patterns and claims emerge from the data that are meaningful and can be well articulated and substantiated. The immersion phase provides structure in the research process. This phase includes immersion in the research topic which is in this case gathering information regarding the development process of ATPs for visually impaired people and what the co-creation approach includes e.g. what is co-creation, what forms/types of co-creation does exist and what co-creation methods/tools are available that can be used for involving the users and stakeholders in the innovation process etc. This part can be referred as extensive literature review. Furthermore, a case study is done to identify the results of using the co-creation approach for engaging blind children in the product development process. The case study includes the results of a project which was successfully performed in 2008 to develop a Wii game for blind children. The second phase is the crystallization phase. We can describe this phase as the process of theory building and developing the conceptual framework, evaluating the conceptual framework with the professionals and if necessary perform changes to improve the proposed theoretical framework.

2.2 Extensive literature review

Besides the standard literature review, this extensive literature review is done (1) to identify the relevant stages in the ATPDP that visually impaired people can be involved, (2) to identify the various types of stakeholders relevant for involving in the ATPDP, (3) to identify different users and stakeholders' involvement methods/tools. In this case we focus on the different co-creation methods/tools that can be applied in the different stages of the innovation process, (4) to identify the different possible scenarios in the development process and (5) to identify what different routes ATP developers can follow etc. To extend and/or support our findings in the literature, we also conducted informal interviews with professionals at different organizations that provide services for visually impaired people. Our findings from the interviews and the extensive literature review are used in theory building and the development of the conceptual framework.

2.3 Case study

The goal in case study research is to understand the boundaries of the case and the complexity of the behavior patterns of the bounded system (Stake R. , 1994). These boundaries are identified by the researcher(s). Researchers may study a single case or multiple cases. A case may be simple or complex. It may be a single patient, a practice, a health care system etc. Case study is defined by individual cases, not by the methods of inquiry used (Stake R. , 1994). Case studies can be qualitative as well as quantitative. Case studies are considered as a research strategy/design and/or an evaluation method. As discussed in previous sections in this study we do a single case study to identify the results of the Wii game project.

2.3.1 Methods used in case study research

A case study research is done to understand the complexity of a case in the most complete way. For this reason, case study research involves the use of multiple methods for collecting data. By using multiple sources of data both qualitative as well as quantitative data the researcher may attain a good understanding of a case. Yin identifies three qualitative methods that can be used in case study research. These methods include participant observation, interviewing and collection of artifacts and texts (Yin, 1989). A short description of each of these methods is given below in Table 2. In this study we use the interviewing and collection of artifacts and texts methods to collect our data. We do not use the method participatory observation because, the project which is the subject of the case study, was performed in 2008.

Case study method	Description
Participant Observation	The term participant observation involves immersing of the researcher himself in the daily lives and routines of whatever is being studied. Participant observation often requires extensive work in the setting that is being studied. It is also called fieldwork. Observation provides the researcher insight into the behavior patterns and social organizations that operate and constitute a particular case.

Interviewing	Interviewing is used by the researchers to learn about the person or persons that are part of the case that is being studied. Many types of formality of interviews exist that researchers can choose e.g. informal, semi-structured or structured interviews. The choice depends on the type of case study and the person that is being interviewed.
Collection of Artifacts and Texts	Another method that researchers may use to learn about a particular case is by collecting and studying artifacts e.g. written protocols, chars, educational handouts, documentation used by the members of the system if a particular system is being studied etc. the type of artifacts being collected is dependent on the type of the case study.

Table 2: Case study methods[6]

2.3.2 Types of case studies

Stake identifies three types of case studies. This includes intrinsic, instrumental and collective case studies (Stake R. , 1994) as shown in Table 3 below.

Type of case study	Description
Intrinsic	An intrinsic case study is aimed at understanding a particular case because the case itself is of interest. A case may be of interest because, it has particular features or because it is ordinary.
Instrumental	An instrumental case study is aimed at providing insight into a problem or issue or to refine an existing theory. The case itself is secondary to understanding a particular phenomenon. The focus in an instrumental case study is that the study is more likely to be known in advance and designed around established theory or methods. The difference between an instrumental and intrinsic case study is not the case but it is the purpose of the study.
Collective	In a collective case study a number of cases are studied jointly in order to understand a phenomenon, population or general condition. This type of case studies is called multiple-case study.

Table 3: Case study types[7]

[6] http://www.qualres.org/HomeCase-3591.html
[7] http://www.qualres.org/HomeCase-3591.html

We use the instrumental case study because, we want to study to what extent the co-creation approach is suitable approach for engaging visually impaired people in the innovation process when developing new product for visually impaired people. Our findings in the case study are used for further theory building related to engaging both the end-users as well as the various types of stakeholders relevant for involving in the ATPDP.

2.4 Informal interviewing

In this study we used the informal interviewing method instead of structured interviewing to retrieve the required information from the professionals. The reason why we chose informal interviewing is the fact that informal interviewing has some interesting characteristics which are relevant for this study. In Table 4 below the characteristics of informal interviewing is listed.

#	Characteristics of informal interviewing
1.	The interviewer talks with people in the field informally, without use of a structured interview guide of any kind.
2.	The researcher tries to remember his or her conversations with informants, and uses jottings or brief notes taken in the field to help in the recall and writing of notes from experiences in the field.
3.	Informal interviewing goes hand-in-hand with participant observation.
4.	While in the field as an observer, informal interviews are casual conversations one might have with the people the researcher is observing.

Table 4: Characteristics of informal interviewing[8]

Furthermore, there are also some known benefits of using informal interviewing. These benefits are listed below in Table 5.

#	Benefits of using informal interviewing
1.	Interviews can be done informally, and, therefore, do not require scheduling time with respondents. In fact, respondents may just see this as 'conversation.'
2.	Informal interviews may, therefore, foster 'low pressure' interactions and allow respondents to speak more freely and openly.

[8] http://www.qualres.org/HomeInfo-3631.html

3.	Informal interviewing can be helpful in building rapport with respondents and in gaining their trust as well as their understanding of a topic, situation, setting, etc.
4.	Informal interviews, similar to unstructured interviews are an essential part of gaining an understanding of a setting and its members' ways of seeing.
5.	Informal interviews can provide the foundation for developing and conducting more structured interviews.

Table 5: Benefits of using informal interviewing[9]

2.5 Research Data

During this study various data has been collected varying in the form of primary data as well as secondary data. This data has been used for theory building and in the development of the conceptual framework for engaging the users and the various types of stakeholders in the different stages of the innovation process when developing ATPs for visually impaired people.

2.6 Next chapter

In the first two chapters we have introduced the research topic and discussed how we are going to conduct this research. We now proceed to the next Chapter, where we provide some background information about what visual impairment includes and the importance of ATPs for visually impaired people.

[9] http://www.qualres.org/HomeInfo-3631.html

Chapter 3: ATPs for visually impaired people

In this Chapter, we provide background information about the terms visual impairment i.e. blindness and low vision which are sometimes used interchangeably. However, these terms differ from each other. Furthermore, we discuss in general terms what the challenges are that visually impaired people experience in daily life. In addition we provide information about what types of ATPs are available and used by visually impaired people. In addition, we explain why it is very important to develop appropriate and acceptable ATPs for these people.

3.1 Visual impairment

Visual impairment limits an individual's ability to perform everyday tasks and affects his/her quality of life. Blindness is the most severe form of visual impairment. Blindness reduces an individual's ability to move about unaided, unless properly trained. The National Eye Institute (NIH) defines low vision as; "even with eyeglasses, contact lenses, medicine or surgery, a person doesn't see well"[10] and the World Health organization (WHO) define low vision as "Low vision is visual acuity less than 6/18 and equal to or better than 3/60 in the better eye with best correction"[11]. The causes of low vision/visual impairment and blindness can be for instance age-related, eye diseases, eye injuries or birth defects, see Table 6 below for a more complete list of possible causes of low vision and blindness and a short description of each term. According to the World Health Organization[12], worldwide there are 285 million people visually impaired. 39 million (14%) of them are blind and 246 million (86%) have a form of low vision.

Possible cause of low vision	Description
Albinism	Albinism is hereditary and results from a lack of pigment. When albinism affects only the eyes then it is called ocular and if it affects skin, hair color and eyes then it is called oculocutaneous.

[10] Information retrieved from: http://www.nei.nih.gov/lowvision/
[11] Information retrieved from: http://www.who.int/blindness/causes/priority/en/index5.html
[12] Information retrieved from: http://www.who.int/mediacentre/factsheets/fs282/en/

Aniridia	The term aniridia refers to the partial or total absence of the iris of the eye. The lack of an iris results in acuity loss, light sensitivity, and visual field loss.
Aphakia	The term aniridia refers to the partial or total absence of the iris of the eye. The lack of an iris results in acuity loss, light sensitivity, and visual field loss.
Cataracts	When the lens of the eye is becoming cloudy or opaque then it is called Cataracts. The clouding can occur over the entire lens or over a small area over the lens.
Coloboma	Coloboma is a birth defect occurring during the development of the fetus. The result is underdevelopment, which results in a cleft in the pupil, iris, lens, retina, choroid or optic nerve.
Glaucoma	Glaucoma is resulting from an increase of pressure inside the eye, often from improper drainage of fluids. Increased pressure can cause damage to eye structures including the optic nerve.
Macular Degeneration	Refers to the gradual loss of sensitivity of the central portion of the retina. This is the area of the retina responsible for detail vision. Macular degeneration is often associated with the loss of central vision and the ability to see fine detail.
Nystagmus	Nystagmus refers to the involuntary movement of the eyes resulting in the inability to maintain a steady fixation. The movement can be horizontal, vertical, circular, or mixed.
Optic Atrophy	Optic Atrophy refers to degeneration of the optic nerve. Loss of function of the optic nerve results in a decreased ability to transmit electrical signals to the visual center of the brain.
Optic Nerve Hypoplasia	Optic Nerve Hypoplasia refers to a condition in which the number of nerves within the optic nerve bundle is reduced.
Retinitis Pigmentosa	Retinitis Pigmentosa refers to a progressive degeneration of the retina resulting in night blindness and peripheral field loss.
Retinopathy of Prematurity	Refers to a condition in which the normal growth of blood vessels in the retina is disturbed during fetal development, often due to circumstances surrounding premature birth. This condition can lead to an increased risk of retinal tears or retinal detachment.

Table 6: Possible causes of low vision[13]

[13] http://www.afb.org/section.aspx?SectionID=26&TopicID=144

The degree of visual impairment can vary from partially sighted to totally blind. Moderate visual impairment combined with severe visual impairment is grouped under the term "low vision". Low vision taken together with blindness represents all visual impairments. In Table 7 below the types of visual impairment is listed and a short description of each term is given.

Classification of visual impairment	Description
Mild-vision loss	20/30 to 20/60 is considered mild vision loss, or near-normal vision.
Moderate visual impairment	20/70 to 20/160 is considered moderate visual impairment, or moderate low vision.
Severe visual impairment	20/200 to 20/400 is considered severe visual impairment or near total blindness.
Profound visual impairment	20/500 to 20/1,000 is considered profound visual impairment or profound low vision.
Near-total blindness	More than 20/1,000 is considered near-total blindness.
Total blindness	No light perception is considered total blindness.
legally blind	Legal blindness is also classified by the WHO. Anyone whose vision cannot be corrected better than 20/200 in their best eye, or who has 20 degrees or less of visual field remaining, is considered legally blind.

Table 7: Classification of visual impairment[14]

Individuals that have low vision can have different amounts of vision/acuity and ways of seeing. Sometimes there is confusion in the use of the terminology surrounding visual impairment e.g. sometimes people may use the terms partially sighted, low vision, legally blind and totally blind interchangeably. However, each of these terms has a different meaning as shown in Table 7. If an individual is partially sighted this means his/her visual acuities are ranging from 20/70 to 20/200. Legal blindness refers to individuals with central visual acuities of 20/200 or less in the better eye with the best possible correction. The term totally blindness is a more

[14] Information retrieved from: http://www.who.int/mediacentre/factsheets/fs282/en/ and http://www.eyehealthweb.com/low-vision/ and http://www.sightsavers.org/our_work/causes_of_blindness/low_vision/default.html?gclid=CIXp-vPkybsCFYlV3godwjMALg

general term used to describe a person with a significant loss of vision who cannot see light or objects.

The meaning of the above mentioned numbers about vision acuity can be explained as follows. An individual who is not visually impaired (normal vision) has vision acuity of 20/20. A vision of 20/40 is considered half as good as nominal vision. A vision of 20/10 is considered twice as good as nominal vision[15]. Now we know this, we can explain how we should read the numbers mentioned above. For instance the expression 20/70 vision acuity indicates that someone with normal vision can see an object from a distance of 70 feet the same object can be seen from a distance of 20 feet by someone who is visually impaired. Thus, the number on the left of the slash symbol indicates from what distance a visually impaired individual can see an object and the number on the right of the slash symbol indicates on what distance the same object can be seen by someone with normal vision. People with loss of vision are experiencing problems in performing tasks in their daily lives. In the next section, we give an overview of what problems those people are facing in daily occupation.

3.2 Challenges that visually impaired people experience

Orientation, mobility and self-navigation or physical movement outside well-known environments is often one of the biggest challenges that visually impaired people are facing. Traveling or walking down a crowded street may pose great difficulty for them. Quite often many people with a visual impairment bring a family member or friend to help navigate unknown environments. Visually impaired people are also facing social challenges e.g. difficulties with participating in activities outside of a workplace, including sports or other social activities. Another challenge is that blindness and visual impairment affects an individual's ability to perform many job duties which may limit an individual's employment opportunities. This may affect an individual's finances as well as self-esteem negatively.

[15] Information retrieved from: http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/raylei.html

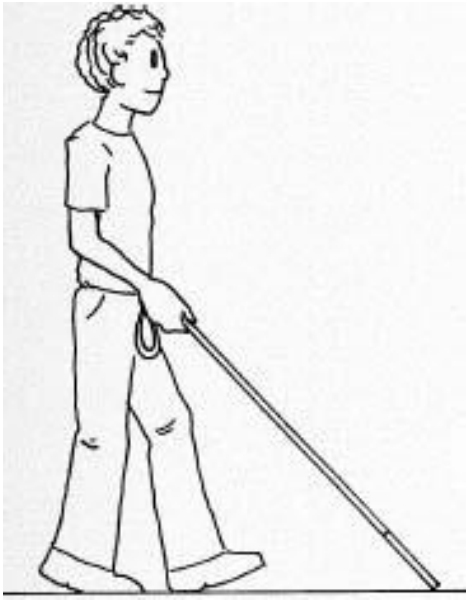

Figure 3: A long white cane used by blind people for navigation[16]

Imagine yourself how you would feel if you would lose your sight, or what people feel who were born blind or visually impaired. It would change your whole life. You would be limited in doing some tasks, or having difficulties with performing daily activities independently. Most of the information that an individual requires is perceived visually which means not being able to see makes things very difficult. Besides the challenges mentioned above there are several other challenges that these people experience in daily life. Think of the things that regular people are used to do in their daily life e.g. preparing for work or school in the morning, reading the newspaper or reading any other standard print papers, driving a car, shopping, watching television, reading street names, doing homework, recognizing faces, recognizing/identification of objects and more similar challenges. Loss of sight would make it difficult or even impossible to perform these activities independently. For people who are not blind or visually impaired it would be hard to imagine how they would perform these activities without being able to see. In order to be able to perform activities independently, a person with loss of sight should learn to live with his/her disability and sometimes this can be a challenge.

[16] Image source: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/sidewalk2/sidewalks202.cfm

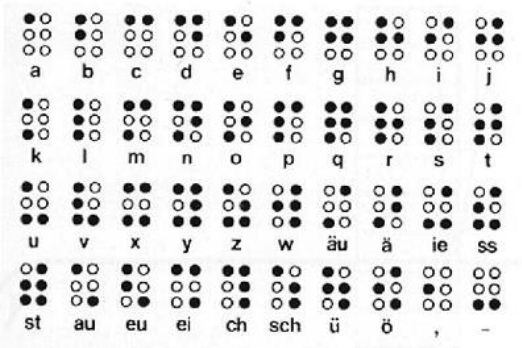

Figure 4: Braille used by blind people to read and write for communication[17]

Loss of vision may affect dignity, productivity and independence of these people negatively. With the help of professionals these people learn solutions that help them solve the problems caused by loss of vision e.g. people who suffer a severe form of visual impairment and/or are blind, use a long white cane see (Figure 3) or sometimes a guide dog to walk down the street and avoid oncoming traffic, or reading and writing Braille (see Figure 4) to communicate with other people. Partially sighted people on the other hand may use a magnifying glass (see Figure 5) or big font size prints to read text.

Figure 5: A magnifying glass used by sighted people to read[18]

There are also technology related challenges that these people experience in daily life including the use of consumer electronics e.g. microwave ovens, washing machine, fridge etc. The use of these devices is difficult because, not many of them are designed to be used by visually impaired people e.g. many of these devices do

[17] Image source : http://www.docukit.nl/inhoud/docukit.asp?nummer=JC86&opmaak=extern
[18] Image source: http://www.100open.com/2011/10/how-diligent-is-your-due-diligence/magnifying-glass/

not support speech in/output which might be very useful for these people, or there is no possibility to set the font size on the (touch) screen which is available on many of these devices. A feature to magnify text on screen would be very useful for partially sighted people. Another challenge is when a visually impaired person is in an anteroom for some reason and is waiting to get some service, where they use a number system. The number is projected on a screen. The font size of that number is often very small and there is no speech output. These are some examples of technology related challenges that these people experience in daily life. And there are more similar challenges.

The aids long white cane, printed Braille on paper and magnifying glass that blind and partially sighted people use to perform daily activities mentioned above are not information technology related solutions. However, in nowadays information technology is used more and more to develop appropriate and acceptable ATPs for these people to help them in performing tasks in their daily lives. In the next section, we provide information about what ATPs for visually impaired people include.

3.3 ATPs for visually impaired people

Assistive technologies (AT) are used to help disabled people to perform various tasks. Without the existence of AT, performing those tasks would be difficult or even impossible to accomplish those tasks. Hersh and Johnson define assistive technology as: "Assistive technology is a generic or umbrella term that covers technologies, equipment, devices, apparatus, services, systems, processes and environmental modifications used by disabled and/or elderly people to overcome the social, infrastructural and other barriers to independence, full participation in society and carrying out activities safely and easily" (Hersh MA, 2008). This definition also applies to assistive technology products because assistive products (AP) are considered a category of assistive technologies. Assistive products are designed to remove barriers for disabled people. Assistive technology serves many categories of disabilities. However, since we in this study specifically focus on visually impaired people, we only discuss assistive technology products that serve the needs of those

people. ATPs can help visually impaired people improve their quality of life and maintain independence. In this study we use the term "assistive technology products" to refer to software, hardware or a combination of hardware and software solutions for visually impaired people.

Assistive technology products	Description
Alternative input devices	These are devices that allow individuals to give input to a computer by using alternative methods instead of the standard keyboard or pointing devices. Some examples of such devices are: alternative keyboards, track balls, joysticks, touch screens etc.
Braille embossers	Braille translation programs convert text scanned-in or generated via standard word processing programs into Braille, which can be printed on the embosser.
Keyboard filters	These are typing aids including word prediction utilities and add-on spelling checkers that reduce the required number of keystrokes.
On-screen keyboards	Provide an image of a standard or modified keyboard on the computer screen that allows the user to select keys with a mouse, touch screen, trackball, or joystick.
Reading tools and learning disabilities programs	Include software and hardware designed to make text-based materials more accessible for people who have difficulty with reading.
Refreshable Braille displays	Refreshable Braille displays mechanically lift small rounded plastic or metal pins as needed to form Braille characters. The user reads the Braille letters with his or her fingers, and then, after a line is read, can refresh the display to read the next line.
Screen enlargers, or screen magnifiers	Works like a magnifying glass for the computer by enlarging a portion of the screen which can increase legibility and make it easier to see items on the computer. Some screen enlargers allow a person to zoom in and out on a particular area of the screen.
Screen readers	Are used to verbalize, or "speak," everything on the screen including text, graphics, control buttons, and menus into a computerized voice that is spoken aloud. In essence, a screen reader transforms a graphic user interface (GUI) into an audio interface.
Speech recognition or voice	Allow people to give commands and enter data using their voices

recognition programs	rather than a mouse or keyboard. Voice input can be used to create text documents including letters or e-mail messages, browse the Internet, and navigate among applications and menus.
Text-to-Speech (TTS) or speech synthesizers	Receive information going to the screen in the form of letters, numbers, and punctuation marks, and then "speak" it out loud in a computerized voice.
Talking and large-print word processors	Software programs that use speech synthesizers to provide auditory feedback of what is typed. Large-print word processors allow the user to view everything in large text without added screen enlargement.

Table 8: Types of assistive technology products[19]

Individuals that have a visual impairment should learn to live with his/her disability as discussed in the previous section. The use of several aids can help them in this process. In nowadays information technology is used more and more to develop ATPs for these people. From the perspective of people with vision loss there are two categories of technology. The first category is mainstream technology which includes computers, smartphones, GPS (Global Positioning System) devices etc. and the second category is assistive technology which includes products that are designed specifically for those people with vision loss. These products include screen readers which are programs that run on a computer and can speak the text that is shown on the screen i.e. in a word processor, web browser, e-mail program or other supported application, Braille watches, Braille printers that can be used by blind people and devices for reading/writing and screen magnifiers that can be used by partially sighted people. There are also stand-alone products designed specifically for visually impaired people, including personal digital assistants (PDAs) and electronic book players that provide portable access to books, phone numbers, appointment calendars etc. Other very useful ATPs are the optical character recognition systems (OCR), a simple setup of an OCR system is shown in Figure 6 below, which can scan printed material and can speak the text. The scanned text can be printed as hard-copy Braille by using Braille embossers (Braille printer).

[19] http://www.microsoft.com/enable/at/types.aspx

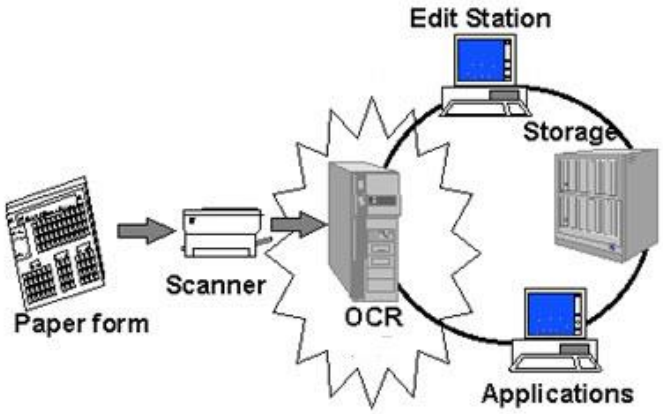

Figure 6: An example of an OCR system[20]

There are various types of ATPs available and used by visually impaired people as we discussed above. The availability of these different types of ATPs is very important for these people because, it can create them an accessible environment and remove barriers which allow them to live and perform daily activities independently.

3.4 Integration of assistive technology

According to Corn AL the term low vision is not only related to visual acuity but often includes an individual's level of visual functioning (Corn AL, 1996). A definition for an individual with a visual impairment who is not functionally blind is an individual who has "difficulty accomplishing visual tasks, even with prescribed corrective lenses, but who can enhance his or her ability to accomplish these tasks with the use of compensatory visual strategies, low vision and other devices, and environmental modifications" (Corn AL, 1996). Low vision or blindness is a loss of eyesight that makes everyday tasks difficult as discussed in the previous sections. When vision cannot be improved with regular eyeglasses or surgery, people that have low vision should learn how to make the most of their remaining sight and keep their independence. Losing vision does not mean giving up your activities, but it does mean finding new ways of performing those activities. ATPs are designed to provide additional accessibility to individuals who have a visual impairment including low

[20] A simple illustration of how an OCR system works. Image retrieved from; http://www.nikhilraichurinnovations.com/2011/12/optical-character-readers-ocr.html

vision or blindness. When selecting ATPs for an individual, it is crucial to find most appropriate and acceptable ATPs for that specific person.

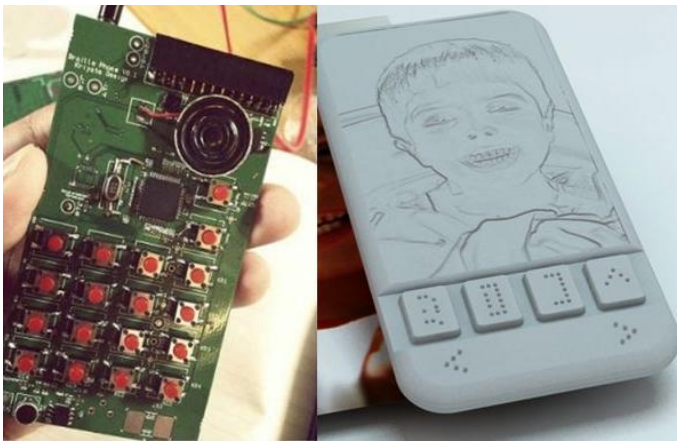

Figure 7: Smartphone with braille-based display for the blind[21]

There are many advantages of using ATPs by visually impaired people e.g. integration of assistive technology into the workplace, the school environment, the home environment, indoors/outdoors mobility, and personal care activities. People who do not have to rely on assistive technology to do their job have a variety of job opportunities to choose from. Their choice is at least not limited because of vision loss. However, for the people who have vision loss the job opportunities and choices are limited. And if they make a choice of the limited amount of available jobs, they still are dependent on assistive technology to perform that certain job. Assistive technology developed in recent years has allowed these people to perform a certain job of their choice along with their colleagues who are not blind or partially sighted. Assistive technology for the workplace includes solutions that can help blind and partially sighted people in performing their tasks for work. Examples of jobs that people that have low vision may perform thanks to the use of assistive technology vary from disciplines including law and government administration to education or to more technical fields including computer programming etc. The use of assistive technology in the different disciplines has resulted in that the job opportunities have been largely expanded.

[21] Image source: http://www.techisdom.com/tag/smartphone-with-braille/

Assistive technology in the school environment includes solutions that can help students that have low vision to do their study. They can use the computer to do their homework or to do research. By using ATPs these students can compete successfully with their peers with normal vision. An example of how assistive technology is being used is for instance a student can read any digital available text, by magnifying that text to a degree that is appropriate or let the computer read it for him/her. If the text is not digitally available, a student still can scan a printed copy of a book to the computer and use assistive technology which is in this case software that either can read or magnify the text on the computer screen to a degree that is appropriate/readable for the student.

Assistive technology in the home environment includes solutions that are intended to make daily tasks easier, safer, or that an individual can do these tasks independently e.g. cooking, dishwashing, vacuum the room etc. Assistive technology should be integrated into consumer electronics to enable visually impaired people to perform those tasks independently. Consumer electronics include for instance microwave ovens, washing machines, vacuum cleaner etc. Assistive technology integration into the home environment not only includes devices that help in performing household tasks independently, but also includes devices that are used for entertainment purposes including smart TV's, DVD/Blu-ray players, set-top boxes etc. integration of assistive technology into these devices enhances the accessibility of these devices for visually impaired people.

Assistive technology for indoor mobility includes solutions that allow blind people to navigate independently within buildings. An example of such solution is a so called sonar system[22]. This sonar system is at the moment in an early stage. The researchers are experimenting with this system to investigate what the possibilities are. The researchers have already developed a device that should allow blind people to "see" again to some extent. This "sonar vision" device can transforms images into sound, enabling the blind to perceive visual information via the ear. In the future this

[22] Information retrieved from: http://www.sciencedaily.com/releases/2008/06/080625153404.htm

sonar system should allow blind people also to navigate outdoors. Assistive technology for outdoor mobility includes solutions that allow partially sighted people to navigate independently outdoors from place A to place B. An example of such solution is specific navigation software which can be installed and used on the smartphone. The navigation software allows partially sighted people to navigate independently in unknown environments which otherwise, they would have to bring someone with them to navigate.

Assistive technology for personal care activates includes solutions that can help visually impaired people in performing those personal care activities e.g. showering, shaving and other grooming. Most likely these personal care activities are done in private and therefore an individual should be able to perform these activities independently. Therefore, it is important to integrate assistive technology into such devices/tools that are used by visually impaired people to perform those personal care activities.

3.5 Next Chapter

In this Chapter, we have provided background information about the terms visual impairment which may vary from partially sighted to blindness depending on how much an individual can see. We described that the terms blindness and visual impairment sometimes may be confused and used interchangeable but, that they have a different meaning. Furthermore, we described briefly what challenges visually impaired people experience in daily life. In addition we provided background information about ATPs available and used by these people and why assistive technology is very important in performing daily activities independently. In the next Chapter, we discuss how this target group and the various types of stakeholders can be involved in developing appropriate and acceptable ATPs.

Chapter 4: Users and stakeholders engagement in the innovation process

The role of users in the innovation process of developing new products is shifting from passive to active participation (Hestad, 2008). We believe that the active participation concept can be applied in developing specific products for specific types of users, (in this case involving visually impaired people in the ATPDP). However, not only the users can play an important role in the innovation process but, also the active participation of the stakeholders can be as much important and useful as the users. More information about the stakeholders relevant for involving in the ATPDP is provided in section 4.3. There are various approaches for involving the users and stakeholders in the innovation process including conventional approaches and new trends i.e. the co-creation approach. In this Chapter, we discuss those different approaches.

4.1 Development of ATPs

Making products without listening to the user can result in products that do not fit the user requirements/needs or the products can be even abandoned by the end-users. Especially when developing products for special types of users are more complex and therefore, the involvement of the end-user becomes even more important. Therefore, we believe it is wise to follow standards and principles that are specifically defined for developing products for people with disabilities, in this case products for blind and partially sighted people. In the paper "Assistive devices for people with disabilities" the authors have identified some principles regarding the production of ATPs[23]. The authors discuss in their paper that these principles should be met to develop appropriate and acceptable ATPs for people with disabilities. These principles are listed below in Table 9.

[23] Information retrieved from: http://www.dinf.ne.jp/doc/english/intl/z15/z15001p1/z1500102.html

#	Principles for the production of ATPs
1	People with disabilities must define their own needs and be involved as equals in designing and testing assistive devices in a problem-solving approach to decision-making that empowers persons with disabilities.
2	The choice and design of assistive devices must suit the user's lifestyle, culture and environment.
3	Devices must be made to fit users, not vice versa.
4	Community-level innovation should be emphasized, and community collaboration with disabled persons and researchers encouraged.
5	Assistive devices should be seen as a part of the process of enabling people with disabilities to achieve their full potential.

Table 9: Principles for the production of ATPs[24]

According to Hersh many features of ATP development are similar to those of other types of product development e.g. consumer products (Hersh, 2010). When developing ATPs, the developers should follow good practice in product design. A list of good practice of product design suggested by Hersh is listed below in Table 10.

#	Good practice of product design
1	User-centered design, with end-users involved throughout the design and development process from the very start (Dvir et al. 2003).
2	Iterative, multi-criteria approaches, which consider function, form, attractiveness to all the senses, pleasure in use, usability, accessibility, performance, reliability, safety and environmental factors. There are a number of different frameworks for taking into account the various factors which should be included in design. These include the Promise Project's six As: awareness, accessibility, availability, appropriateness (usefulness), affordability and acceptability (CEN 2003).
3	Appropriate trade-offs between (1) the provision of different modes of use and/or inputs and outputs and information in different formats, with a degree of redundancy, and (2) simplicity and cost. Factor (1) will generally improve accessibility and usability for disabled and elderly people, as long as the product does not become (over)-complicated as a result. Excessive cost

[24] Information retrieved from: http://www.dinf.ne.jp/doc/english/intl/z15/z15001p1/z1500102.html

	will act as a barrier, whether users purchase the device directly or with financial support from a third party.
4	Ease of upgrading, repair and maintenance, as well as robust design to reduce the likelihood of faults occurring. This has benefits to both end-users and the environment. Minimization of negative environmental impacts over the whole life cycle will make it easier to meet legislative requirements and could make the product more attractive to some users and, in some cases, will reduce costs.
5	Ease and intuitiveness of use, with a minimum of documentation and training, as well as consideration of the subsequent provision of information, support and repair facilities to end-users.
6	A modular software architecture, to reduce the impact of any problems that occur in any one component on the rest of the design and to facilitate the later addition of further modules.
7	Compliance with any relevant national and international standards or other regulation. Good design practice generally goes beyond minimal compliance and can lead to commercial advantage if the standards or regulations become stricter due to the greater ease and reduced costs of proactive rather than reactive compliance.

Table 10: Good practice of product design[25]

However, Hersh identifies four differences in the development of ATPs in comparison to other types of product development. These differences are listed below in Table 11. When developing new ATPs, the following two conditions should be met (1) the standard good design practices (see the list in Table 10) and (2) interfaces which are accessible to disabled people (in this case the blind and partially sighted people).

#	Differences between the design of ATPs and other types of products
1	Many, though not all, assistive devices are developed for relatively small numbers of users and sometimes even a single person. There are examples of assistive products for which there is widespread demand, including hearing aids and wheeled mobility frames for elderly people. However, an assistive project is more likely to develop a large market sector if it has additional applications for non-disabled people.
2	The small numbers of potential users of many assistive devices has resulted in a number of 'non-standard' routes to the conception, design, further development and distribution of assistive products.

[25] Information retrieved from: http://cirrie.buffalo.edu/encyclopedia/en/article/309/

3	Since, assistive products are often supplied to users by health or social services or non-governmental organizations, the immediate purchaser is often not the end-user. Therefore, the design may need to satisfy both the end-user and the funder or purchasing organization.
4	Many standard user interfaces in consumer products are inaccessible or difficult to use by particular groups of disabled and/or older people.

Table 11: Differences between the design of ATPs and other types of products [26]

4.2 The users

We use the term "user" or "end-user" to refer to people who use, wish to use, or have used ATPs. In this study we focus on how to involve these users of ATPs i.e. children, adults or elderly people with a visual impairment in the innovation process. As we mentioned in previous sections, we believe that especially ATPs should not be developed in the absence of contribution of special types of users because, those people are the ultimate evaluators and/or assessors whether an assistive product is appropriate and acceptable. They can provide information about the user requirement and/or other interesting ideas related to designing appropriate and acceptable ATPs. Contribution includes consultation with and the participation of the end-users in the innovation process. Using sophisticated technology to design ATPs without user involvement may lead to the production of sophisticated assistive products with no relevance to users' lives and needs and this may lead that the users may abandon newly developed ATPs as discussed in section 1.1.

We believe that visually impaired people who potentially will use the ATP in question should be involved from conceptualization through to the market deployment process. The best way to realize this is to include the users directly as members of the decision-making team during gathering the user requirements, formulation and monitoring of the project and the phase which includes the assessment and evaluation of the assistive product. It is also very important that an ATP first needs to be field-tested among a group of potential users before it is produced and brought to the market. Users can spell out their requirements qualitatively. In the test phase for instance, they may notice that some functionality

[26] Information retrieved from: http://cirrie.buffalo.edu/encyclopedia/en/article/309/

of a prototype ATP is not functioning according to what they have expected from that assistive product e.g. the text on the screen cannot be magnified to the desired degree. This requirement is of course translated into quantitative terms by the R&D people or engineers in order to make adjustments to solve that problem. This is done based on discussions with the end-users.

4.3 The Stakeholders

In order to develop appropriate and acceptable ATPs for visually impaired people, the users should be involved in the development process as discussed in section 4.2. However, not only the users can play an important role in providing valuable/useful information in developing appropriate and acceptable ATPs but, also involving the various types of stakeholders can be as much useful as the users. In the literature the term stakeholder is defined as (1) "Anyone affected by an issue, who may or may not be formally involved in decision making about the issue" (Coretta Mallery, 2012) and (2) "Anyone who might influence an organization's ability to achieve its mission or who can provide input on whether the mission is achieved" (Coretta Mallery, 2012). We define the stakeholders in this study as "voluntarily participating non-users in a project who in some ways (formally or informally) have a relationship with the end-users of ATPs and may have insight in the user requirements which allow them to easily and objectively asses/observe from outside what those user requirements/needs are and what kind of aid these users require in performing some tasks". In product development there are commercial as well as non-commercial stakeholders. In this study we focus on the non-commercial stakeholders in ATP development.

We classify the users and the stakeholders on the same level because, we consider the stakeholders here as people who just want to contribute/participate in the development process and provide information which may be useful in designing appropriate and acceptable ATPs, the same we expect from the end-users. In other words in the ATPDP, we consider stakeholders as volunteers who want to contribute/participate in the project without having any "commercial" expectations

for their own sake. The meaning of the term stakeholder in other types of product development projects (e.g. mainstream product development) may be different. In other types of product development the stakeholders have their own interest in the project. In that case we cannot classify them on the same level. They need to be separated into two groups including end-users and stakeholders with different interests in a particular project. However, this is out of the scope of this project. Furthermore, we distinguish in two types of stakeholders including the "non-professional stakeholders" and the "professional stakeholders". The definition of these two types of stakeholders is given in the next two sub-sections. The reason why we distinguish in two types of stakeholders is because, each type of stakeholder has his/her own look at a particular problem/solution. For instance, the non-professional stakeholders can provide information that is not well structured but, the provided information may be very useful because of their close relationship with the end-users. This information can be translated by professionals/designers into relevant and understandable user requirements. On the other hand, the professional stakeholders have a professional look on a particular problem/solution. They may provide more structured information but, this information may not be the same as the information that non-professional stakeholders can provide. The professional stakeholders may also have a relationship with the end-users but, in most cases they do not have a close relationship as the non-professional stakeholders. Therefore we believe it is wise/essential to distinguish in these two types of stakeholders. Moreover, we believe that the input of both types of stakeholders may be very useful in the design process because, they both look from their own perspectives on a particular problem and/or solution. Furthermore, we decided to use the term "stakeholder" to refer on both professionals as well as non-professionals because, after these people have been selected to participate in a project, besides that they become a team member of that project/innovation team they also automatically become a stakeholders of that particular project. It is not a prerequisite to involve all the suggested stakeholders in the framework in a project. ATP developers may choose the ones that are relevant in a particular project.

4.3.1 Non-professional stakeholders

In the context of developing ATPs, the non-professional stakeholders include the family members, acquaintances, friends, colleagues, teachers in regular schools, caregivers (a caregiver is anyone who is not a health professional, but gives care to for instance disabled people. In this case the disabled people are people with visual impairments). We use the term non-professional stakeholders because, we define them as people who are in some way "informally" in touch (have close relationship) with the users of ATPs. These people can assess/observe from outside what problems visually impaired people are experiencing and perhaps have suggestions on how to solve those problems. They may also suggest functionality that an aid should possess to support the user with a visual impairment in performing some tasks or they may even come up with complete new ideas/suggestions related to ATP design.

4.3.2 Professional stakeholders

Besides the non-professional stakeholders mentioned in sub-section 4.3.1, there are also the so called professional stakeholders e.g. ophthalmologists, opticians etc. that can be engaged in the innovation process. A more complete list of professional stakeholders and a short description of each stakeholder is provided in Appendix B. We use the term professional stakeholders because we define them as people who are in some way "formally" in touch with the users of ATPs. Similar to non-professional stakeholders the professional stakeholders can also assess/observe from outside what challenges visually impaired people are experiencing and perhaps have suggestions on how to solve those problems. Like the non-professional stakeholders, they may also suggest functionality that an aid should possess to support the users with a visual impairment in performing some tasks or they may even come up with complete new ideas/suggestions related to ATP design.

4.4 Conventional approaches in product design

Michael Porter reported in his work that the process of value creation should be driven almost exclusively within the firm (expert driven design) (Porter, 1985).

Product design and production could be performed in-house with minimal consumer (end-user) input. In expert driven design a product is designed by experts for people. In this approach the belief is that the experts understand what users think, what they want and what the user behavior is. Therefore, there is no need to involve these users in the innovation process (active firm - passive user approach). In this approach the role of the consumer was seen solely at the end-of-line points of consumer interaction, not during the process of value creation. A widely held belief and often stated comment was that consumers weren't creative.

Over time this notion has changed. A new approach in product design was emerged. This new approach was User-Centered Design (UCD). This of course does not mean that the expert-driven design approach is disappeared, rather a new concept (User Centered Design) was introduced. User-Centered Design is an approach where the needs and limitations of the end-users of a product are given attention by the experts at each stage of the product lifecycle (Norman D. A., 1986). In User-Centered Design the notion is that the end-users are the experts of their everyday lives experience which makes them potential sources of innovation (Norman D. A., 1988). User-Centered Design is a multi-stage problem solving approach. In this approach not only the experts of the product analyze and foresee how users like to use a particular product, but it also requires real world tests with actual users to test the assumptions of the experts about user behavior (Sugar, 1995). Testing is necessary to understand intuitively what the users of a product experience when using it and whether the product fits the user requirements/needs. The philosophy of UCD is to optimize the product around how users can, want or need to use the product. It does not force the users to change their behavior when using that product.

Over the years the manufacturers have realized and were convinced that the user can be an important source of innovation in new product development. Shumpeter defines innovation as (1) "The introduction of a new good or a new quality of the good", (2) "The introduction of a new method of production", (3) "The opening of a new market", (4) "The conquest of a new source of supply", and (5)

"The carrying out of the new organization of an industry" (Schumpeter, 1934). In other words Innovation is "the process of translating an idea or invention into a good or service that creates value or for which customers will pay"[27]. Bogers, Afuah & Bastian define user innovation as innovation by intermediate users e.g. user firms or consumer users e.g. individual end-users or user communities, rather than by suppliers e.g. producers or manufacturers (Bogers, Afuah, & Bastian, 2010). Bendapudi & Leone discuss in their paper that the studies from begin 80's through 90's focused on a firm-centric approach (Bendapudi & Leone, 2003). The belief was that increased productivity can be realized through involvement of the customer in product design. At that time the idea was that increased productivity gains could be achieved through passing on tasks from the firm to the users. The belief was that customer participation may help increase quality. In contrast, Czepiel suggested that customers' participation may lead to greater customer's satisfaction (Czepiel, 1990). Manufacturers started looking for ways to involve the users in the product design process. In his book Eric Hipel observed that many products and services were actually developed or at least refined at the site of implementation and used by users (Hippel, 1988). User innovation includes innovation in services, configuration of technologies, use and innovation in novel technologies. User innovation is mostly concentrated in use and configuration of existing products/technologies. New channels of communication including social media are making user innovation much easier.

In the paper "From User-Centered Design to Participatory Design Approaches" the author suggests that in product design there is a shift from a User-Centered Design approach to a Participatory Design Approach (Sanders, 1999). Participatory Design (PD) is a subdivision of User Centered Design where the users and stakeholders are all actively involved in the innovation process to help ensure the product is usable and meets all the user needs (Schuler, 1993). According to the research institute DAIMI[28] PD consists of four key elements i.e. cooperation, experimentation, contextualization, and iteration. There is an in-between space

[27] Information retrieved from: http://www.businessdictionary.com/definition/innovation.html
[28] http://www.daimi.au.dk/research/areas/human-computer-interaction/participatory-design/

which users and developers/designers meet as equals which is named the "Third Space". This space is imagined as an opportunity to learning experiences, challenging stereotypes, identity formation, and development of new and innovative ideas through cultural, social, and political negotiations. The innovation process encompasses several systematic steps, beginning from problem/requirement analysis to idea generation, idea evaluation, project planning, product development and testing to finally product marketing. In Participatory Design participants i.e. users and stakeholders are invited to cooperate with designers, researchers and developers during the innovation process. The participants participate in the different stages of the innovation process including participation in the initial exploration and problem definition phase through to deployment to the market and the other stages in between these two stages in the product lifecycle. In the PD approach the attitude is that the users are the partners during the design process. The experts are actually not designing for users but they are designing with users for the users. The term PD is used in various fields including software design, graphic design, planning and of course product design. PD is not a design style but, instead it is an approach that focuses on processes and procedures of product design. PD is seen as an approach that ensures democratization in product design because it advocates and values the perspective, knowledge, skills and involvement of the end-user when designing a product. There is no single definition of PD because it stretches across a wide range of perspectives, backgrounds, and areas of concern. One of the definitions of PD in the literature is as follows "Participatory Design is an approach to the assessment, design, and development of technological and organizational systems. The impetus of PD is to encourage the active involvement of potential or current end-users of a system in the design and decision-making processes".[29]

We use the term "user involvement" and "stakeholders' involvement", to refer to the active involvement of the end-users (in this case the ATP users) and the stakeholders, not their passive involvement as recipients. Involving is often described

[29] Note: this definition is given by the Stanford University computer science faculty: http://www-cs-faculty.stanford.edu/~eroberts/cs181/projects/participatory-design/history.html

as doing things with or by people for people. "Involvement" covers a range of activities, from consulting product/service users and stakeholders about their views or wishes, through to working in partnership with them to develop products or services. Involving the users and the various types of stakeholders in the different stages of product development can be realized through using various types of methods. A list of methods is provided below in Table 12.

#	User involvement methods
1	Brain storming session(s)
2	Discussion with users
3	Ethnography
4	Expert users meeting
5	First human use
6	Focus groups
7	Interviews
8	Observations
9	Surveys
10	Think about method
11	Usability tests
12	Users-producers seminars
13	User feedback

Table 12: List of conventional user involvement methods in product design[30]

Another approach in product design is 'Human-Centered Design" (HCD) which is introduced and used by IDEO[31]. They use the term "Human-Centered Design" to refer to User-Centered Design describing their own view in UCD. In the next section, we will have a closer look on what IDEO's Human-Centered Design approach in new product development includes.

[30] Note: the methods listed in this table are identified by the authors of the paper: "Developing medical device technologies from users;' perspectives: A theoretical framework for involving users in the development process". We show these methods to illustrate how users are involved in the different stages in medical device development. We will not go in detail how these methods are being applied because it is out of the scope of this study. In this study we focus on the co-creation approach.
[31] IDEO is a global design and innovation-consulting firm that takes a human-centered, design-based approach to helping organizations in the public and private sectors innovate and grow. Information retrieved from: http://www.ideo.com/about/

4.5 IDEO's Human-Centered Design approach

As discussed in the previous section, traditionally product designers focused on the product itself i.e. adding more features, enhancing functionality or the look of a product to gain higher profits. In nowadays designers tend to use design tools to tackle complex problems e.g. finding new ways to provide low-cost products or services. In the paper "Design Thinking for Social Innovation" the authors discuss that businesses were first to embrace the new approach which is called "design thinking" and that now non-profit organizations are beginning to adopt it too (Tim Brown, 2010). Tim brown, president and CEO[32] of IDEO defines Design thinking as "Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success"[33]. The term "design thinking" was first used by IDEO. In 2008, IDEO introduced their Human Centered Design toolkit, a methodology organizations can use to undertake the design thinking process themselves (IDEO, 2008). The Human Centered Design toolkit was a result of a project which was carried out by IDEO. The Bill & Melinda Gates Foundation asked IDEO to codify the process of design thinking, so that it could be used by grassroots non-governmental organizations working with small farmers in the developing world. A team of IDEO designers have worked with various organizations[34] to understand the processes of the participating organizations for designing new products, services, and integrate them with IDEO's own processes.

IDEO's Human-Centered Design approach is a process consisting of a set of tools which designers can choose the techniques that best work in a context and situation to create solutions i.e. products, services. It is possible to use the toolkit alone or in combination with other methods that are already being used in an organization for creating and implementing new ideas. In the Human-Centered Design approach the people to whom the product is being developed, are seen in the

[32] The abbreviation CEO stands for "Chief Executive Officer". Information retrieved from: http://acronyms.thefreedictionary.com/CEO
[33] Information retrieved from: http://www.ideo.com/about/
[34] The organizations that were involved in the project are; Heifer International, the International Center for Research on Women, and International Development Enterprises

center of the design process because, they are the ones who know best what the right solutions are for a particular problem that they want to be solved. In addition only the user knows how to best use that particular product. IDEO believes that the user needs/requirements should not be captured using conventional methods i.e. interviews, surveys etc. because, they believe that the users cannot express these user needs/requirements. Instead they believe that the designers should hear, understand and capture the user needs/requirements in new ways based on the users' behavior and create innovative solutions to meet these needs/requirements (IDEO, 2008). Monitoring the users' behavior is very important because that way more appropriate solutions can be created. An example that is discussed in IDEO's HCD toolkit is that HCD surprised the designers on how people were able to create so many solutions, even those people didn't know a lot about the topic (IDEO, 2008). According to IDEO the benefits of the Human-Centered Design approach are (1) it can help an organization connect better with the people they serve, (2) It can transform data into actionable ideas, (3) It can help you to see new opportunities, and (4) It can help to increase the speed and effectiveness of creating new solutions (IDEO, 2008). Furthermore, in the HCD toolkit IDEO describes how the HCD process works. The HCD process starts with a design challenge and goes through three phases which IDEO call (1) Hear, (2) Create, and (3) Deliver. The process moves the design team from concrete observation about people, to abstract thinking as the team uncovers insights about the problem and which then leads to the creation of concrete solutions to solve that particular problem. In the "Hear phase", the design team collects stories and inspiration from people through preparing and conducting field research. In the "Create phase", the team works in a workshop format to translate what they heard from people into frameworks, opportunities, solutions, and prototypes. In this phase the team moves from concrete ideas to more abstract thinking in identifying opportunities which will then lead to the creation of solutions and prototypes. The third and final phase is the "Deliver phase" which describes activities related to launching the product e.g. revenue and cost modeling, capabilities assessment, and implementation planning.

As we discussed above "design thinking" which IDEO applies in their design activities is a "Human-Centered" approach. IDEO believes that thinking like a designer can transform the way organizations develop products, services, process, and strategy[35]. IDEO suggests that "the solutions that emerge at the end of the Human-Centered Design should hit the overlap of three lenses which brings three aspects together as shown in Figure 8. This includes (1) desirability i.e. what do people desire? (2) feasibility i.e. what is technically and organizationally feasible?, and (3) viability i.e. what can be financially/economically viable?" (IDEO, 2008). In addition it also allows people who aren't trained as designers to use creative tools to address challenges.

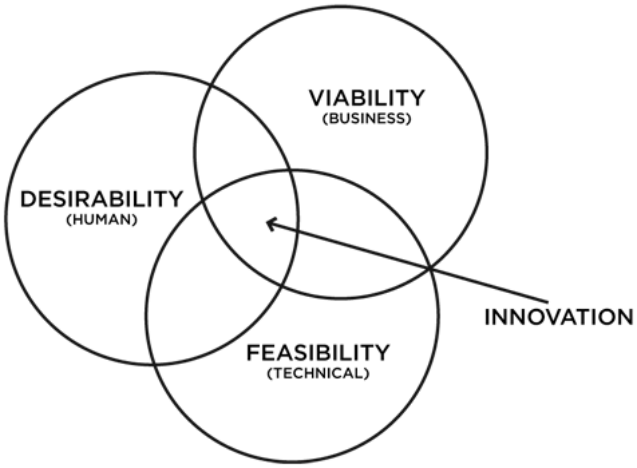

Figure 8: IDEO's human-centered approach to innovation[36]

Design thinking is an alternative for conventional problem-solving approaches e.g. expert-driven design. It is a deeply human process that taps into the abilities that people possess i.e. it relies on the ability of people to be intuitive, to recognize patterns, to construct ideas that are emotionally meaningful as well as functional, and to express themselves through means beyond words or symbols. However relying only on people's ability as described above may not give the desired results. Rational and analytical thinking of the designers is as much as important. Therefore, combining these two aspects can provide the desired result. The design thinking

[35] Information retrieved from: http://www.ideo.com/about/
[36] Image source: http://www.ideo.com/about/

approach integrates these two aspects. In design thinking the situation and people's needs/requirements are analyzed in a problem-based way. This ensures that the solutions are offered in a more effective ways.

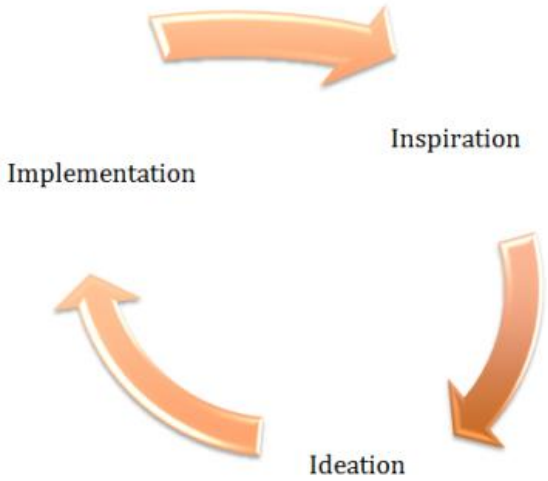

Figure 9: The design thinking process[37]

There are three steps/spaces in the design thinking process i.e. inspiration, ideation, and implementation as shown in Figure 9. The process should be seen as a system of overlapping spaces rather than a sequence of orderly steps. The design thinking process starts with detecting a problem or opportunity that motivates people to find/come up with solutions. IDEO calls this phase inspiration. The next phase is ideation which is the process of generating, developing, and testing ideas. And the implementation phase is the path that leads from the project stage into people's lives.

In the previous section, we discussed some conventional approaches in product design. In the context of product development, the term conventional refers to conforming to the usual practices of accepted standards when developing new products[38]. In addition in this section, we discussed IDEO's HCD approach which also can be considered a conventional approach. In the next section, we look at the new

[37] Image source: http://couldbecasestudies.wordpress.com/design-thinking-overview/
[38] Information retrieved from: http://vocabulary-vocabulary.com/dictionary/conventional.php

trend in Participatory Design which is an alternative to conventional approaches. This new approach is the co-creation approach. With the co-creation approach not only the experts design by asking input and feedback of the users and the stakeholders to involve them in the design process but, it goes a step further by engaging them in the product design process to ensure that they are part of the whole design process from the very beginning to the end. Therefore, we believe this approach can lead to the creation of appropriate and acceptable ATPs for visually impaired people. According to the website "trendwatching.com"[39] customers are becoming not only co-designers, but also manufacturers. That website used also the words "User manufacturing" to refer to co-creation.

4.6 The co-creation approach

In section 4.4, we gave a brief overview of the conventional approaches in product design. In this section, we discuss the new trend in PD which is the co-creation approach. The term co-creation is also used in the field of marketing e.g. sales and branding activities. However, in this study we only focus on how co-creation is applied in product development. There are a number of definitions in the literature for the term "co-creation" including (1) "A business strategy focusing on customer experience and interactive relationships. Co-creation allows and encourages a more active involvement from the customer to create a value rich experience"[40] and (2) "Co-creation is a very broad term with a broad range of applications. Co-creation is defined as any act of collective creativity that is experienced jointly by two or more people. How is co-creation different from collaboration? It is a special case of collaboration where the intent is to create something that is not known in advance"[41]. Before we describe the concept of co-creation in detail and how it is applied in product development, we first want to discuss what users and stakeholders' engagement means in product design and why we believe it is important that the users and stakeholders should get engaged in the innovation process.

[39] Information retrieved from: http://www.trendwatching.com/
[40] Information retrieved from: http://www.businessdictionary.com/definition/co-creation.html
[41] Information retrieved from: http://www.osbr.ca/ojs/index.php/osbr/article/view/1012/973

Prior studies suggest that engagement consists of users' activities, attitudes, (Kappelman, 1995), goals and mental models, and motor skills (Said, 2004), and that it manifests itself in the form of attention, intrinsic interest, curiosity, and motivation (Chapman, 1997). John Byrne defines user engagement as "user engagement is how we nurture and build a community"[42]. Furthermore, in the literature the term user engagement is described as (1) "user engagement is a quality of user experience that emphasizes the positive aspect of interaction in particular the fact of being captivated by the technology" (Lalmas, 2012) and (2) "The emotional, cognitive and/or behavioral connection that exists, at any point in time and over time, between a user and a technological resource" (Simon Attfield, 2011). The term "user engagement" is either used in "the digital world" e.g. how many times per day is a website accessed by a user or how much time does a user spend on a website etc. and "other tangible products" e.g. how many times a day a product for instance a smartphone is used and how much time does the user spend on using that product etc. In addition the term "user engagement" is used in "product design" e.g. is the user willing to participate in the design process and under what conditions/what role does the user have in the innovation process or how much time is he willing to spend in the design process and if the user is willing to participate how should a manufacturer organize this etc. In this study we focus on how the term is used in product design. Furthermore, we use the term "stakeholders' engagement" to describe the involvement of other people than the end-users that may participate in the innovation process. In the conceptual framework that we introduce in Chapter 6, we identify those users and stakeholders that are relevant in ATP development for visually impaired people and we describe how they can be engaged in the innovation process. Users and stakeholders engagement not only includes involvement as discussed in section 4.4, but it also includes active participation and having a clear role in the innovation process. Characteristics of user engagement and a short description of each term are listed in Table 13 below.

[42] John Byrne, Business Weeks' online editor 2009

Characteristic	Description
Focused attention	Users must be focused to be engaged. Distortions in the subjective perception of time used to measure it.
Positive affect	Emotions experienced by user are intrinsically motivating. Initial affective hook can induce a desire for exploration, active discovery or participation.
Aesthetics	Sensory: visual appeal of interface stimulates and promotes focused attention.
Endurable	People remember enjoyable, useful, engaging experiences and want to repeat them.
Novelty, surprise, unfamiliarity, and unexpected	Appeal to user curiosity, encourages inquisitive behavior and promotes repeated engagement.
Richness and control	Richness captures the growth potential of an activity and control captures the extent to which a person is able to achieve this growth potential.
Reputation, trust and expectation	Trust is a necessary condition for user engagement. Implicit contract among people and entities which is more than technological
Motivation, interests, incentives and benefits	Difficulties in setting up "laboratory" style experiments.

Table 13: Characteristics of user engagement[43]

Forrester research has identified the four "I's" of user engagement including involvement, interaction, intimacy and influence. These terms are listed in Table 14 below and a short description of each term is given.

Term	Description
Involvement	Presence of a user
Interaction	Action of a user
Intimacy	Affection or aversion of a user
Influence	Likelihood a user advocates

Table 14: The four "I's" of user engagement

[43] The information listed in this table is retrieved from the paper "User Engagement – A Scientific Challenge"

The concept of co-creation was introduced in 2000 by C.K. Prahalad and Venkat Ramaswamy in their article, "Co-Opting Customer Competence". They developed their arguments further in their book "The Future of Competition" where they offered examples showing that customers would no longer be satisfied with making yes or no decisions on what a company offers. Prahalad and Venkat Ramaswamy define co-creation as "a form of market or business strategy that emphasizes the generation and ongoing realization of mutual firm-customer value. It views markets as forums for firms and active customers to share, combine and renew each other's resources and capabilities to create value through new forms of interaction, service and learning mechanisms. It differs from the traditional active firm - passive consumer market construct of the past" (Ramaswamy C. K., 2000). Furthermore, co-creation is not considered as a tool or methodology rather it is a mindset/approach for engaging people in the development of products and services.

The early applications of co-creation were more related to branding and marketing activities to engage the customers. These innovations in customer engagement and collaboration expanded and morphed during the mid-2000s into global economic trends including the co-creation of products and services. At that time many theories were developed based on co-creation and customer collaboration e.g. crowdsourcing which is coined by Jeff Howe (Howe, 2006), Henry Chesbrough introduced open innovation (Chesbrough, 2003) and Don Tapscott and Anthony D. Williams published their book discussing how corporations are using mass collaboration and open source innovation (Tapscott & Williams, 2008). Sam Lucente, design and innovation guru at Hewlett-Packard (HP), said that designers can no longer design products alone, using their brilliance and magic. They are no longer in the business of product and service design. He stated that they are really in the business of customer co-creation[44]. The term co-creation is often used synonymously with related ideas including open innovation, collaborative innovation, customer-led innovation etc. (active-users in the innovation process). It differs from the traditional

[44] Information retrieved from: http://www.businessweek.com/innovate/NussbaumOnDesign/archives/2006/01/ces--when_consu.html

active firm - passive user construction which we discuss in section 4.4. The stages in the innovation process include users being integrated in the early stages i.e. ideation and concept development and the later stages i.e. product design, testing, or launching the new product to the market. Product designers use the term co-creation to encompass the entire process of design and production. Co-creation can be seen as an approach for inclusive, creative and meaningful engagement of the users as well as the stakeholders in the different stages of the innovation process. Co-creation brings manufacturers and users together on the same level. In general terms the co-creation process can be visualized as shown in Figure 10 below.

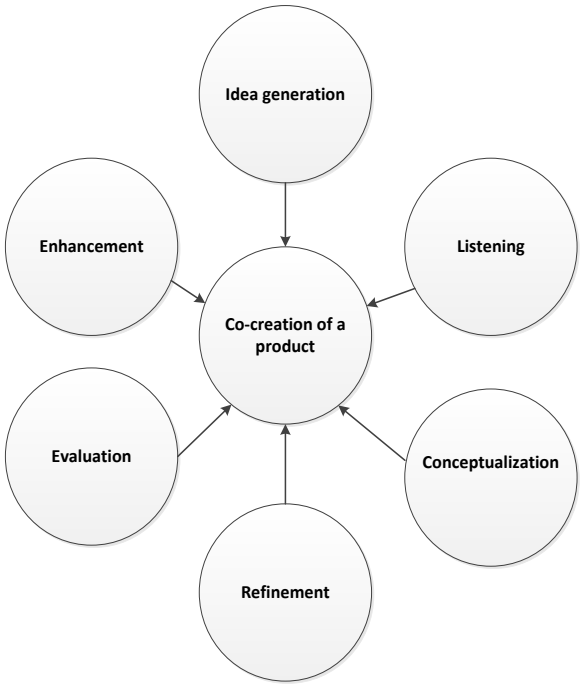

Figure 10: Co-creation process visualized[45]

In the paper "Co-creation: a typology and conceptual framework" the authors identify twelve forms of co-creation (Pennie Frow, 2010). Some of these forms of co-creation are used in product design, others are used in the stages after design stage including distribution, promotion and pricing. A list of these forms of co-creation including a short description of each term is provided in Table 15 below. In addition

[45] Note this figure is derived from the image which was published on the website http://yannigroth.com/2011/06/08/hyves-ceo-michael-bartl-about-using-web-communities-and-the-long-tail-for-market-research/

in the paper "co-design and co-deployment methodologies for innovative m-learning systems" the authors suggest the term co-deployment as a form of co-creation (D. Millard, 2008). Furthermore, we will be using the term "co-prototyping" (collaborative prototyping) as a form of co-creation. The term collaborative prototyping was used by Willem Horst in the paper "Supportive tools for collaborative prototyping" (Horst, 2011). In the conceptual framework that we introduce in Chapter 6, we will incorporate four relevant forms of co-creation that can be used in the different stages of ATP development. More information about the four forms of co-creation that we incorporate in the framework is provided in section 6.3. Furthermore, the different stages in the ATP lifecycle relevant for engaging users and stakeholders is discussed in section 6.2.

#	Form of co-creation	Description
1	Co-conception of ideas	Refers to two or more actors collaborating on product concept innovation.
2	Co-design	Refers to two or more actors sharing their respective design perspectives.
3	Co-production	Refers to two or more actors jointly produce all or part of the firms offering.
4	Co-promotion	Refers to two or more actors collaborating on promotional activities related to a specific product, service,
5	Co-pricing	Refers to collaborative pricing decisions that involve two or more actors and reflects their joint pricing perspectives.
6	Co-distribution	Refers to two or more actors collaborate to distribute goods and services, usually for en-user consumption.
7	Co-consumption	Involves collaboration during usage, as actors employ their resources (physical, social and/or cultural), individually or collectively, as co-consumer to determine and enhance their own consumption experiences.
8	Co-maintenance	Refers to two or more actors sharing in the maintenance services of a product.
9	Co-outsourcing	Refers to two or more actors, including suppliers, customers, competitors, or other actors collaborating in outsourced solutions.

10	Co-disposal	Refers to two or more actors collaboration in disposal tasks e.g. usage of recycled boxes.
11	Co-experience	Involves actors integrating their resources over time and across multiple encounters creating a shared experience with different outcomes than those occurring in more discrete individual interactions.
12	Co-meaning	Refers to interactions between actors that produce new meanings and knowledge through multiple encounters over time.

Table 15: Forms of co-creation

The philosophy of co-creation is about "bringing the users, stakeholders and product designers together and building it with them". Co-creation harnesses human potential to mutually expand value by attaching meaning to their experiences of outcomes and their acts of creative interactions with the environments around them[46]. Schrage suggests that with co-creation the users are not just customizing a product rather they are collaborating with the manufacturers to create unique value (Schrage, 1995). The co-creation approach is successfully used in many different projects for engaging regular users in the innovation process for developing mainstream products. However, there are not many examples available of using the co-creation approach for engaging visually impaired people in developing ATPs. One of the limited available examples in the literature shows the successful application of the co-creation approach for engaging visually impaired children in product development. Therefore, we do a case study on this subject to explore to what extent the co-creation approach is a suitable approach for engaging visually impaired people in the ATPDP. We discuss our findings of the case study in Chapter 5.

[46] Information retrieved from: http://wbi.worldbank.org/wbi/devoutreach/article/1304/co-creating-development

Figure 11: Solving the puzzle on your own[47]

Figure 12: Solving the puzzle all together (co-creation)

Like the proverb "two heads are better than one" says (see Figure 12, for a simple illustration of this thought), we believe that visually impaired people and the relevant stakeholders should get engaged in the different stages of the ATPDP as discussed in previous sections. In order to develop appropriate and acceptable products, they need to be given the opportunity to share and discuss their ideas with the designers and where necessary even perform other activities that is defined in the co-creation approach. The question is how should the product designers organize this? In order to ensure that the interaction between users, stakeholders and the product designer(s) happens in an effective and efficient way, it is required that a framework exist that the decision makers can consult. Using a framework can help them in making the right decision about selection of the end-users and relevant stakeholders, what methods/tools in what stage of the innovation process can be used for engaging these users and stakeholders. Until now the co-creation approach has been successfully used in various projects as mentioned above. Each manufacturer used its own approach for the co-creation of products. Researchers created different frameworks that describe how the co-creation approach can be used in product design (Thorsten Roser, 2005), (Per Kristensson, 2007), (Ingrid Mulder), (Stappers, 2008), (Seppo Leminen, 2011), (Bartl, 2009). The co-creation approach is flexible and adaptable and therefore very suitable to meet the needs of both the users as well as various types of stakeholders. Each manufacturer may choose to use the methods/tools that best fit their requirements in a particular project. In Chapter 6, we introduce our theoretical framework that describes what

[47] Note this figure is derived from the image which was published on the website: http://www.noesissolutions.com/Noesis/process-optimization/plugin-framework

co-creation forms and co-creation methods/tools can be used in the different stages of the ATPDP.

4.7 Next Chapter

In this Chapter, we discussed the development process of ATPs. We showed that designing mainstream and assistive products have minor differences. We defined the users of ATPs and the relevant stakeholders that can be involved in the ATPDP. We discussed different approaches that are used in product design including conventional approaches i.e. expert-driven design and user-centered design. Furthermore, we looked at what IDEO's Human-Centered Design approach includes. In addition we discussed the new trend in product design which is the co-creation approach. We showed why we choose the co-creation approach over conventional approaches for engaging the users and the different stakeholders in the innovation process. We now proceed to the next Chapter, where we discuss our findings of the case study.

Chapter 5: Case study findings

We are all equal in our desire when it comes to playing video games. Gaming should be available to everyone, regardless of what disabilities a person has i.e. blind or partially sighted because, everyone loves gaming. A blind person should not say the words "I can't" when it comes to playing video games. However, a game should not only be playable individually by blind or visually impaired people, nor these people should be able to play games only with their blind or partially sighted peers but, they also should be able to play a game along with their peers with normal vision on an equal level. The playing field can be either leveled using assistive devices which visually impaired people can use for gaming or games can be developed that are playable both by the blind as well as people with normal vision at the same time on equal basis. With this objective in mind in 2011 Royal Visio expertise center for blind and partially sighted people in the Netherlands has introduced worldwide a unique game 'The Explorer and the Mystery of the Diamond Scarab" for the Wii game console. The game made it possible that children with and without visual impairments were for the first time able to play a game on an equal level. The main reason why this project is interesting and relevant for our research project is because, in that project the co-creation approach has been successful applied for involving blind children and children with normal vision in the development of the Wii game. Therefore, we decided to explore this project and use this project as a reference to justify our choice of incorporating the co-creation approach in our theoretical framework for engaging visually impaired people and the various types of stakeholders in the ATPDP. We studied the project documentation and publications related to that project to gain understanding of what the project included i.e. the purpose of the project, who worked on it and how the project was carried out. In addition we interviewed the person who was responsible for the co-creation process in that project, to explore what the experiences were of the different people i.e. the children and the professionals who were involved in the project. In this Chapter, we discuss our findings on this subject.

5.1 The game

In 2008 the partners MAD Multimedia[48], Principal Blue[49], TNO[50] and Royal Visio decided to give the concept of "Serious Gaming"[51] a new dimension. The main reason to develop a "Serious Game" was to create a challenging and motivating learning environment for this special target group. In addition It was also important that the game should create a challenging experience for the children with normal vision because, the thought behind this game was that it should be playable by both blind as well as children with normal vision, using the same interface on a an equal level. The reason why Royal Visio classifies this game as a "Serious Game" is because, (1) the game promotes the integration of visually impaired children and (2) the game also helps to improve locomotor skills[52] development and physical coordination of blind children. Professionals at Royal Visio have indicated that the Wii game console was selected because playing games with the Balance Board requires players to move their body. This type of kinesthetic play is beneficiary for the balance and locomotive development of blind children. With a subsidy from the Innovative Action Programme Groningen (IAG2), in two years the first official Nintendo Wii game for blind children and children with normal vision was developed. During this project the co-creation approach has been used. In the so called GAMBAS project (GAMes for the Blind and Sighted) TNO has created a co-creation process and anchored this with the development process of the game. Along with the developers blind, partially sighted and children with normal vision have contributed to the content and form of the game. At the end of the development process the game is evaluated with the special target group for further optimization of the gameplay and control. The

[48] Develops, produces and distributes interactive concepts and complete online campaigns.
[49] It is a network organization that focuses mainly on counseling organizations that introduce new technological developments.
[50] They assist companies, authorities and, public and semi-public organizations to innovate successfully in the area of ICT.
[51] Serious Games are generally held to be applications developed with game technology and design principles having training, situation simulation or education while entertaining the user as a prime purpose. Serious Gaming is, thus, games that engage users in their pursuit and contribute to the achievement of a defined purpose other than pure entertainment. Information retrieved from: http://www.ludus-project.eu/seriousgaming.html
[52] Locomotor skills are a category of motor skills. They are a group of movements in which the feet move the body from one place to another. Information retrieved from; http://familyfitness.about.com/od/fitnessvocabularyterms/g/locomotor.htm

project was closed with the evaluation of the objectives of the project along with the participants.

An important starting point for developing this game was that there was no game available that can be played both by blind children and children with normal vision, where the blind children have the same chance of winning the game as children with normal vision. Children with normal vision cannot follow the games (audio games) that are specifically developed for blind children. They miss the social aspect i.e. encouraging each other when playing the game. Blind and partially sighted children have indicated that they would like to measure up to their fully sighted peers. Therefore, Royal Visio has decided to start this project to bring the social aspect in the gaming experience when these children play together a game. Furthermore, prior research shows that locomotor skills development in children with a visual disability usually trails behind of children with normal vision (Houwen, 2008). Professionals at Royal Visio believe that playing a game with a balance board can stimulate locomotor skills development. During this project physical therapists, exercise specialists and teachers had a clear role in the co-creation process. The locomotor challenges for the game were defined in collaboration with these professionals at Royal Visio.

In the game, the user plays Ben, the archaeologist, who is looking for the Temple of the Scarab Diamonds. Once he lands in the temple, he meets Tiri, an enchanted Egyptian princess. Together they try to escape from the temple with all its dangers. In a labyrinth of underground passages they search for the ancient Egyptian treasures and confront various exciting challenges. The Guard leads them step by step to the exit. The game is played on a balance board which is a standard Wii-console accessory. To navigate through the labyrinth, the player needs to stand on the balance board and lean in the direction he/she wants to move. If you are near a wall you hear the sound of grit, if you are on a side corridor then you hear the sound of the wind and if you are near the treasure you hear a twinkling sound. The twinkling sound gets faster as you get closer to the treasure. The developers have chosen to use these different sounds to make sure that the blind children get an idea

of the environment to make the right movements to get to the target as fast as possible. When evaluating the game the developers observed that if the footsteps make a different sound in each direction, this helped a blind child to "look" how other children with normal vision are playing. That way, a blind child could help a child with normal vision to find the treasure. The game can be played by blind, partially sighted and children with no visual disabilities between the ages of six and twelve years.

5.2 Co-creation of the Wii game

Innovation in the health sector takes place in a rapid pace. Where until recently the knowledge and skills of the professionals determined the offer, it is in nowadays slowly shifting to increasingly involving the users in the development of new products or services. As we discussed in section 4.6, co-creation is one of the approaches that can be used to give users a clear role in the innovation process. From the very beginning to the end, the users are actively involved in the innovation process. The value and view of the end-users are seen as leading in the development process. Royal Visio followed this trend and they decided to develop the Wii game through a co-creation process. Blind, partially sighted children and their brothers/sisters with normal vision participated in the project during the entire development process. They were part of a multidisciplinary team consisting of (1) Royal Visio with experts regarding the development of blind children i.e. physical therapists, exercise specialists, teachers, ICT specialist and application specialist for the blind, (2) MAD Multimedia with educational games developers, (3) Principal Blue for project management and (4) TNO for the creation and execution of the co-creation strategy. In this section, we discuss how the co-creation process is created and applied in the project.

The co-creation process was started with the selection of the participants. Four families with blind, partially sighted and children with normal vision between

the ages of seven and twelve years were selected. Through mind maps[53], the children were made aware of the games they like to play i.e. would they like to play inside/outside or alone/together etc. After brainstorming about what games they would like to play, per game, they were asked to think about the elements that makes a game enjoyable for them. To ensure that all children design the same kind of game, they were asked to choose all the game elements that they wanted in the game. Through a card trading game, four shared favorite game elements were selected from the total list of game elements that were mentioned by the children i.e. (1) experience adventures, (2) be smart, (3) learn new things and (4) laughing. In order to ensure the children were able to develop a Wii game, they were asked to experience playing with the Wii game console for a period of two weeks and to think about the following aspects i.e. (1) things they like, (2) things they find difficult and (3) come up with ideas to make the Wii game console more suitable for the blind. Coming up with a game was done in two steps. In the first place it was done through skits in the group with all the participating children. Then the initial idea was further developed in small groups, each group consisted of a blind child, a child with normal vision and a facilitator[54]. Within the small groups elaboration was carried out by using LEGO bricks and small toy figurines. Multiple ideas emerged in the individual idea phase. These ideas were merged into a coherent concept. Then a list of shared concepts was drawn up by providing the children the possibility to vote on each other's idea and asking them the motivation behind their choice. From the vote results the developers concluded that rummaging through a labyrinth, dodging traps and collecting treasures were enthusiastically received by the children.

After the concept was defined, it was time to build the game. Based on the shared concepts a detailed game concept was designed by the game developers. To get feedback as early as possible, a prototype of the concept was built and tested before building the actual game. Because it was not possible to submit screens to the

[53] A mind map is a graphical way to represent ideas and concepts. It is a visual thinking tool that helps structuring information. Information retrieved rom; http://litemind.com/what-is-mind-mapping/
[54] A facilitator is someone who leads/organizes the co-creation process. The facilitator can be seen as a middle-man who steers the co-creation process. He/she has knowledge/skills in the field of doing research, product design and project management.

blind children, instead the synopsis of the game with corresponding sounds was read. The physical environment was simulated in a gym. The children could "experience" the game by completing a track in the gym and the interaction was simulated with musical instruments. The software development methodology scrum[55] was used to develop the game. In each sprint/iteration[56] a small piece of software was developed tested and evaluated. At the beginning the focus was mainly on navigation and equivalence. In later versions more game and fun elements were developed. During development, the intermediate results were evaluated with the children who were participating in the project. In the final phase, to get feedback about the game, the game was also evaluated by a new group of children who were not involved in the development process. Based on the results of the evaluations, the navigation and orientation elements were evolved to make it easier to maneuver and create more sense of direction and distance for the blind and partially sighted players. While blind, partially sighted and children with normal vision contributed to the content and form of the game, physical therapists, exercise specialists and teachers monitored the motoric aspects.

5.3 Experiences with the co-creation approach

We spoke with several people i.e. one of the facilitators who organized the co-creation process and professionals at Royal Visio who were involved in the Wii game project, to explore how they experienced the co-creation approach in the projects i.e. how was the experience for the participating organizations, how did the children experience it, what was the added value of co-creation and what were the challenges of using the co-creation approach. Professionals at Royal Visio have indicated that the project was a very instructive experience for them and the other participating organizations. Using the co-creation approach as development process had a prominent role. Working together with partners/organizations from different

[55] Scrum is a methodology used in software development. It emphasizes the idea of "empirical process control." That is, Scrum uses the real-world progress of a project, not a best guess or uninformed forecast to plan and schedule releases. Information retrieved from: http://scrummethodology.com/

[56] In the Scrum method of agile software development, work is confined to a regular, repeatable work cycle, known as a sprint or iteration. Information retrieved from: http://scrummethodology.com/scrum-sprint/

sectors has proven its value. With the combined knowledge and experience of the participating partners an innovative and high quality product was delivered. In addition they said that without the enthusiastic contribution of the participating children and therapists, the project would not be so successful. The evaluations and opinions of the end-users were the guidelines during the development process. A lot of solutions implemented in the game were created by the children during the co-creation sessions.

During co-creation end-users are involved as experts of their experiences (Stappers, 2008), not as game designers. By using the co-creation approach the developers wanted the children to become aware of their fun/interesting gaming experiences and preferences. The facilitator who was responsible for the co-creation process and who was one of the co-authors of the paper "Involving blind children in the co-design of a Wii game" indicated that co-creation is a very suitable approach for designing for visually impaired people, because it offers the developers many valuable insights and experiences i.e. it helps developers and designers to envision how blind/visually impaired children experience their world and interact with games (Liliane Kuiper, 2010)[57]. By making the children part of the development/innovation team, they can be involved in different stages of design and implementation process. They can steer the design decisions and evaluate intermediate results. Furthermore, she indicated that during the Wii game project their experience was that the co-creation approach can be adapted very well for special target groups to create meaningful participation and involvement. The added value of co-creation within the project was that the children have really contributed to the final design of the game. Because the developers worked closely together with the children, they gained many valuable insights which helped them to come up with an acceptable game design. Beside the children, professionals within Royal Visio were similarly involved in the development process. They provided useful information about to what extent a child with a visual impairment is capable to perform a particular co-creation task and

[57] Note: The paper was a publication about the co-creation of a WII game. In the paper the authors discuss their experiences of using the co-creation approach for involving blind, partially sighted and children with normal vision in the development process of the game.

under what conditions those tasks can be performed. Furthermore, they were responsible for defining the motoric aspects as discussed in the previous section which was an important element of the game.

According to the facilitator of the project the role of a facilitator is difficult because, on one hand it is important to let the children be as creative as possible and on the other hand, they need to remain focused on the design process and not get lost in just creating adventures. To keep this in balance, the facilitator let the children design small parts of the complete design and then asked them specific questions about the design so far. Furthermore, the facilitator has indicated that user involvement is particularly important when designing for children with (visual) disabilities because, it is difficult for designers to envision the limitations and possibilities for this target group. However, it is a challenge to reach high levels of participation using the same collaboration techniques used for people with normal vision. In consultation with the professionals at Royal Visio the facilitators improvised and adapted the usual co-creation methods to the capabilities of blind children and to make it fun for them to participate. The professionals at Royal Visio indicated that blind children cannot be asked to draw images. Nor is it easy for them to oversee and make selections from a large list of items. In addition it is also more difficult to make them experience and evaluate intermediate results on paper. In the project the children performed several roles i.e. (1) the role of an end-user for testing the final version of the game, (2) the role of a tester for testing and evaluation of consecutive versions of the working prototype on the Wii game console, (3) the role of an Informant for collecting data and commenting on sketches and prototypes and (4) their most important role was that of design partner i.e. they were involved in creating design solutions and they could steer the design decisions and evaluate intermediate results.

5.4 Evaluation of the Wii game project

Gaming technology continues to evolve and video games are used more and more in education and in health and social care institutions (Kato, 2010). The Wii

game which was developed by Royal Visio is a good example of using gaming technology in health care because, as we discussed in section 5.1, besides the social and fun elements in the game, the game was classified as a "Serious game" because, the game had the purpose of being used to improve locomotor skills of blind children.

During the official launch of the game the children who participated in the project have been interviewed by radio and TV stations. The children have proudly introduced themselves as one of the developers of the game. The game was developed based on the ideas and wishes of the blind children and children with normal vision. This created a game that relates to the perception of both groups and is suitable for all children regardless of whether they are visually impaired or not. In several primary schools of Royal Visio blind and partially sighted children tried out the game and they indicated that they were enthusiastic about the game and that they felt engaged in the game. Professionals at Royal Visio who were involved in the project indicated that it is a challenge to develop an instructive Wii game that offers sufficient challenge to all children i.e. ones with normal vision, partial vision or blind children and at the same time that it is fun to play. However, they managed to develop a game that was very successful. Involving the children from the beginning through the end of the development process resulted in that the ideas and wishes of the children were implemented at once during the development process. Evaluation of the project which took place at the end of the development process showed that there was not much time needed for making major adjustments to the game because, the game already broadly met the wishes and needs of the children. This resulted in that the game was developed in a relatively short period of time. Royal Visio indicated that the organization is extremely proud and the organization will start with new projects in the future whereby interaction with the clients will play an important role.

The success of the game is also confirmed by the "Oogfonds"[58]. The "Oogfonds innovation award" was awarded to Royal Visio for developing the Wii game. The jury praised and considered that Royal Visio has put a major step forward with the development of the new Wii game to promote integration of blind, partially sighted children and children with normal vision. In addition, the jury believed that Royal Visio responded well to the hype of using co-creation in product development. They were pleased to see that the co-creation approach was used during the Wii game project to involve the children in the development process.

5.5 Limitations of the case study

One of the limitations of this case study is that we did a single case study. Doing a multiple case study would increase the reliability of the findings (Stake R. E., 2006). However, due to time constraints this was not possible in this study. Furthermore, the fact that we have chosen to do a case study on the Wii game project can be seen as a limitation because, (1) children were as end-users involved in that project which means we do not know whether involving blind and partially sighted adults and elderly people in designing products for this special target group would result in a similar positive outcome, and (2) it is also possible that in the Netherlands or in other countries, projects might exist where the results of using the co-creation approach for engaging special types of end-users did not give the desired outcomes. However, we have not found any evidence showing negative results of using co-creation for developing products for visually impaired people. Another limitation that we recognize is that because of the project was performed in the period of 2008-2010 we did not have the opportunity to talk with the children who participated in the project to explorer what their opinions/experiences were from their perspectives. On the other hand, we had the opportunity to interview the facilitator of the project who was responsible for the co-creation process. During the interview we asked her how she experienced the project and what her thoughts

[58] The oogfonds is an organization in the Netherlands. The organization focuses on (1) conduct scientific research, (2) create an accessible world for blind and visually impaired people, (3) reducing unnecessary blindness (prevention) and (4) advocacy of blind and sighted people. More information about the organization can be found at: http://oogfonds.nl/

were about how the children experienced the project at that time. Furthermore, in that project only live/onsite sessions took place which means the children were always physically present in the co-creation sessions. In the project online co-creation was not used. This means that we do not know to what extent using online co-creation as we describe in section 6.4 is effective and efficient for engaging this special target group in the innovation process. However, we believe that online co-creation can be effectively used, if the proposed methods/tools are adapted so that the special target group can use them. This of course needs to be tested in real life projects to explore to what extent the online co-creation concept can work.

5.6 Next Chapter

In this Chapter, we discussed how the Wii game for blind, partially sighted children and children with normal vision was developed by Royal Visio and its partners. Firstly we introduced the case study topic and described what partners participated and what their role was in the project. Then we described what the purpose was of developing such game. Furthermore, we had a closer look on how the co-creation approach was applied to involve the children in the design process. In addition we provided information about how the different organizations and the children have experienced the co-creation approach in the project. Furthermore, we provided information about what the project outcome was. The case study showed that using the co-creation approach for involving special target groups is important, relevant and meaningful. We now proceed to the next Chapter, where we introduce our conceptual framework. We describe what the framework includes i.e. the different stages in ATP development, the scenarios and the different routes which developers can follow when designing ATPs for visually impaired people.

Chapter 6: The proposed conceptual framework

In this Chapter, we introduce our conceptual framework and we discuss how ATP developers can use this framework as a reference for engaging users and stakeholders in the innovation process of ATP development. As we discussed in Chapter 4, co-creation is a new trend in product development and there is a growing acceptance that it may change the way manufacturers view the role of the end-users in creating new products. However, much remains unknown about how these users can get engaged in the co-creation process. When we look at ATP development for visually impaired people, we see a similar situation. We believe a systematic and formal approach is required to realize this. Therefore, we introduce a theoretical framework which ATP developers can help in making decisions about how those users can get engaged in the innovation process. As discussed in Chapter 5, according to the people who were involved in the Wii game project, a co-creation approach is very suitable for designing for people with visual disabilities because, it helps developers and designers to envision how blind/visually impaired people experience their world. Furthermore, we believe that the co-creation approach can be very useful in situations where visually impaired people and people with normal vision have to work together in a project because, the methods/tools supporting co-creation can be adapted to meet the specific needs of both types of participants i.e. visually impaired people and people with normal vision. Applying the co-creation approach gives ATP developers the possibility and the freedom to use different methods/tools for engaging the end-users and the various types of stakeholders in the innovation process.

Bearing in mind (1) the findings in prior research regarding under-use and abandonment of assistive devices by the end-users, (2) the positive results of using the co-creation approach in the Wii game project as discussed in Chapter 5, and (3) numerous of success stories which many manufacturers had when using the co-creation approach in different projects for engaging regular users and stakeholders in the innovation process, we propose that ATP developers can use our theoretical

framework which we introduce in the next section for engaging both end-users (visually impaired people) as well as the stakeholders (people with normal vision) in the ATPDP.

6.1 ATP Co-creation framework

The co-creation approach requires methods/tools for capturing the user needs/requirements, ideas. In addition it gives the end-users the ability to share user experiences and to work together with the product designers (in this case ATP designers). In this section, based on our finding in the literature and the case study we identify several methods/tools that can support co-creation activates which forms the basis of our theoretical framework. The proposed framework can be seen as a practical guide for the creation and assessment of ATPs. After defining the goal, the scope and the target group, this framework can be consulted by ATP designers for making decisions about the selection of different routes, the stakeholders that are relevant to be involved in a particular project, what methods/tools to use in what stages of ATP development for engaging the end-users and the different stakeholders. Co-creation can be seen as a new way (approach) to give users agency to advocate, act and create their own desirable situations. Users collaborate in each stage of the innovation process starting from idea generation and concept development to concept testing in context and market deployment. An effective use of co-creation can be realized by combining the users' needs with the expertise of ATP developers. In other words "for a true co-creation process to work effectively the end-users need to be placed explicitly at the same level of importance as the developers" (Urbick). A generic framework which developers can consult to organize co-creation sessions can be very useful. As shown in Figure 13, in the framework we propose to use four forms of co-creation that can be applied in the four stages of ATP development i.e. co-idea generation in stage 1, co-design in stage 2, co-prototyping in stage 3 and co-deployment in stage 4. In section 6.2 a detailed description of these four stages relevant for engaging users and stakeholders in ATP development is provided. In each stage we suggest different methods/tools to support co-creation activities in each stages of the innovation process. A detailed

description of methods/tools supporting co-creation activities is provided in section 6.4. Furthermore, the framework shows the possible routes i.e. users, stakeholders etc. which ATP developers can choose to follow when developing ATPs as we discuss in section 6.6. In addition the users and the different stakeholders that we believe are relevant to be involved in ATP development for visually impaired people is illustrated in the framework. A list of the various types of stakeholders and a short description is provided in Appendix B. Another part of the framework consists of the different possible scenarios in ATP development which we discuss in section 6.5.

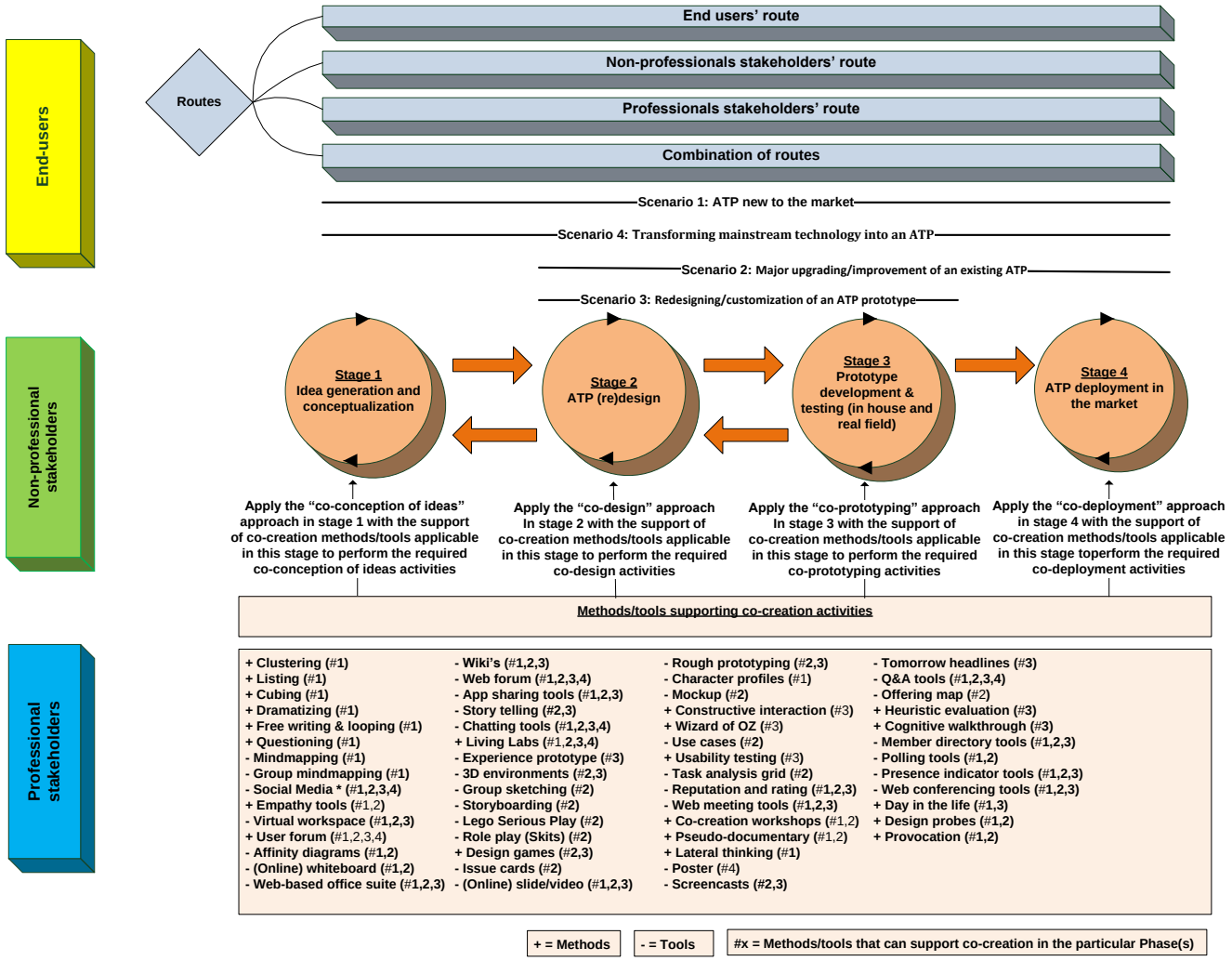

Figure 13: ATP co-creation framework

6.2 Stages in the ATPDP relevant for engaging users and stakeholders

Hersh suggests that the end-users can be involved in the innovation and evaluation process of ATPs (Hersh, 2010). Similar to regular product development, the development process of ATPs can also be divided into several stages. As we mentioned in previous sections, ATPs are considered a form of a medical device. Literature review shows that the lifecycle of a medical device consists of five stages including (1) concept stage, (2) design stage, (3) testing and trials stage, (4) production stage and (5) deployment stage (Shah SGS, 2006). Furthermore, in the paper "Developing medical devices technologies from users perspective" the authors describe that the users can be involved in four of the above mentioned stages including (1) idea generation/concept development stage, (2) design/prototype development stage, (3) prototype/testing stage and (4) depyloyment stage (Syed Ghulam Sarwar Shah I. R., 2009). We therefore have incorporated these four stages in our theoretical framework. However, we have added prototype development and testing in the same stage (in stage 3) instead of adding prototype development in stage 2 as the authors above suggest because, we believe prototype development and testing can happen in the same stage. Adding prototype development and testing in the same stage can be beneficial e.g. the developed prototype can be tested in the same stage before it goes to the next stage. This can increase efficiently and quality and faster development. In addition separating design stage and prototyping stage can also be beneficial because, we believe that the design should comply with the predefined requirements in stage 1, before it is passed to the next stage which is prototype development and testing. This is an ongoing iteration in stage 2 and stage 3 that takes place until the prototype is functioning as desired. Furthermore, we suggest different co-creation forms, that best fit in each stage of the ATP development process including the methods/tools that can be used to support the co-creation activities in a particular stage. Besides the above mentioned stages relevant for engaging users in the innovation process, there is also a stage that comes prior to the actual development process which is market exploration. The market exploration phase is a pre-phase of the actual development process. In this

phase the starting point for a new product is defined including the context, scope, the users, the technology that will be used etc. In other words, in the pre-phase the developers do research on the desirability, viability and feasibility of the product. We do not incorporate this phase in our theoretical framework, since we in this study only focus on the actual development process.

6.3 Co-creation in the different ATP development stages

Literature review and the case study shows that, before any co-creation sessions are conducted, a series of self-awareness exercises should be done that allow participants to reflect on everyday activities that they would normally take for granted (Stappers, 2008), (Liliane Kuiper, 2010). After these self-awareness exercises, the actual co-creation process can start. We propose to use different co-creation forms in the different stages of the innovation process as shown in Figure 13. In stage 1 we suggest ATP developers to apply the "co-conception of ideas" approach. Co-conception of ideas refers to two or more actors collaborating on product concept innovation. In stage 2 we suggest to apply the "co-design" approach. Co-design refers to two or more actors sharing their respective design perspectives. In stage 3 we suggest to apply the "co-prototyping" approach. Co-prototyping refers to two or more actors sharing their respective prototyping and testing perspectives. We suggest that the prototypes should be built by the team members (experts) who have those technical skills, because building prototypes might require technical skills i.e. programming etc. However, making changes/adjustments on the prototype can be done based on the input they get from the end-users and the different stakeholders in the prototyping phase. Therefore, the suggested methods/tools in the co-prototyping approach are especially meant to support usability testing activities, enabling conversations and information sharing. And in stage 4 we suggest ATP developers to apply the "co-deployment" approach. Co-deployment refers to two or more actors sharing their respective deployment perspectives. Co-deployment is the process of involving the end-users and the different stakeholders in the deployment and evaluation phase of an ATP. In this phase the end-users may share their experiences regarding product launch and/or give feedback on post-

deployment in the market to assess and evaluate the ATP performance. The four co-creation approaches discussed in this section can be applied in the four stages of the innovation process with the support of methods/tools applicable in each stage as suggested in the framework to perform the required co-creation activities. A description of co-creation methods/tools is given in section 6.4.

6.4 Methods/tools

In section 4.3, we mentioned that we classify users and stakeholders on the same level. We propose to use the co-creation approach to create a situation whereby the end-users as well as the various types of stakeholders can get engaged in the ATPDP by providing them the required co-creation methods/tools in each stage. A list of co-creation methods/tools and a short description of each item is provided in Appendix A. The proposed methods/tools can support either online as well as onsite co-creation activities. The reason why we propose to use both online as well as onsite co-creation is because, onsite co-creation is very useful in situation where ATP developers choose to bring the users and stakeholders physically on the same table to collaborate (live sessions). Online co-creation on the other hand is very useful in situations where the developers choose to work on a project where the users, different stakeholders and the experts can work on the project from a distance. We define the term "online co-creation" as the participation/contribution of the end-users and/or stakeholders in the innovation process from a distance by making use of Information Technology. We believe that online co-creation can be applied especially for engaging the various types of stakeholders in the innovation process because, sometimes it may happen that those people cannot attend an onsite co-creation session because of time limitations. Applying online co-creation can increase flexibility and efficiency which can create a new ideal situation/concept "Design Anytime, Anywhere and Anyplace". In addition applying online co-creation for involving the end-user can also be useful because, visually impaired people are more comfortable when they can work from their known (home) environment, instead of going to an (unknown) place to participate in a project where they may feel uncomfortable.

Applying only online co-creation has the disadvantage that the target group can get smaller because, people can encounter barriers when using computer technology (Watering, 2005). These barriers can vary from cost, the user-friendliness of equipment and unfamiliarity, resistance of people to adopt technology. These barriers are less compared to e.g. children or adults because these two groups do more often use computer technology in contrast to elderly people. Therefore, we believe that the decision of applying onsite or online co-creation should be made by ATP developers based on the type of product they would like to develop and the target group they would like to invite to participate in the project. We believe that an ideal situation can be created when ATP developers use a combination of online and onsite co-creation approaches to engage the users and the stakeholders in the innovation process. In addition using a combination of onsite and online co-creation approach ensures that the target group does not get smaller.

The proposed standard method/tools supporting co-creation activities can be easily used by people with normal vision e.g. the professional and non-professional stakeholders. However, these methods/tools need to be adapted in order to make them accessible for visually impaired people. Blind people for instance have different requirement regarding accessibility in contrast to partially sighted people e.g. blind people cannot perceive images while partially sighted people might be able to perceive images but not as good as people with normal vision. Furthermore, within the group of partially sighted people, there are also differences in the level of acuity. The adaptations to the suggested methods/tools are dependent on the degree of vision loss and the target group i.e. children, adults or elderly people that is participating in the project. In consultation with the experts i.e. physical therapists, exercise specialists, teacher etc. and the users who are participating in the project, the facilitators can improvise and adapt the usual co-creation methods/tools to the capabilities of blind and partially sighted people as the facilitators did in the Wii game project. The suggested methods/tools are generic and optional. Therefore, the developers may choose the relevant ones for a particular project. It is not a prerequisite to make use of all the suggested methods/tools in a project at the same time. The choice of the developers may be influenced by the route they want to

follow e.g. will they follow the users' route, stakeholders' route or a combination of these routes. A detailed description of the possible routes in ATP development is provided in section 6.6. Another factor influencing their choice might be the scenarios. As we discuss in section 6.5, there are different scenarios possible in ATP development whereby each scenario requires different methods/tools for engaging the users and stakeholders in the innovation process.

6.5 ATP development scenarios

Similar to other types of (mainstream) product development, the ATP development process is an iterative process beginning with idea generation and conceptualization through to design, prototype development and testing and deployment to the market (Bridgelal Ram M, 2008). We believe that engaging the users and stakeholders can happen through iterative process which takes place at different points in the innovation process of ATP development as shown in Figure 13. In the paper "Developing medical devices technologies from users' perspective" the authors identify three scenarios in designing medical devices. These scenarios include (1) development of a medical device new to the market, (2) major upgrade of an existing medical device and (3) redesign of a prototype (Syed Ghulam Sarwar Shah I. R., 2009). These scenarios are also applicable when developing ATPs because, as mention in previous sections, ATPs are considered as a form of a medical device. In addition we address a new scenario which can be useful in ATP development. We name this new scenario "transforming mainstream technology into an ATP". These four scenarios in ATP development are discussed in the following sub-sections.

6.5.1 Scenario 1: development of an ATP new to the market

The first scenario in ATP development is "developing an ATP new to the market". In this scenario the development process is an ongoing iteration process starting from conceptualization stage through to the market deployment of the ATP. This iterative process between the four stages is illustrated below in Figure 14. In this scenario the users as well as the various types of stakeholders can be engaged in the different stages depending on the chosen route as discussed in section 6.6.

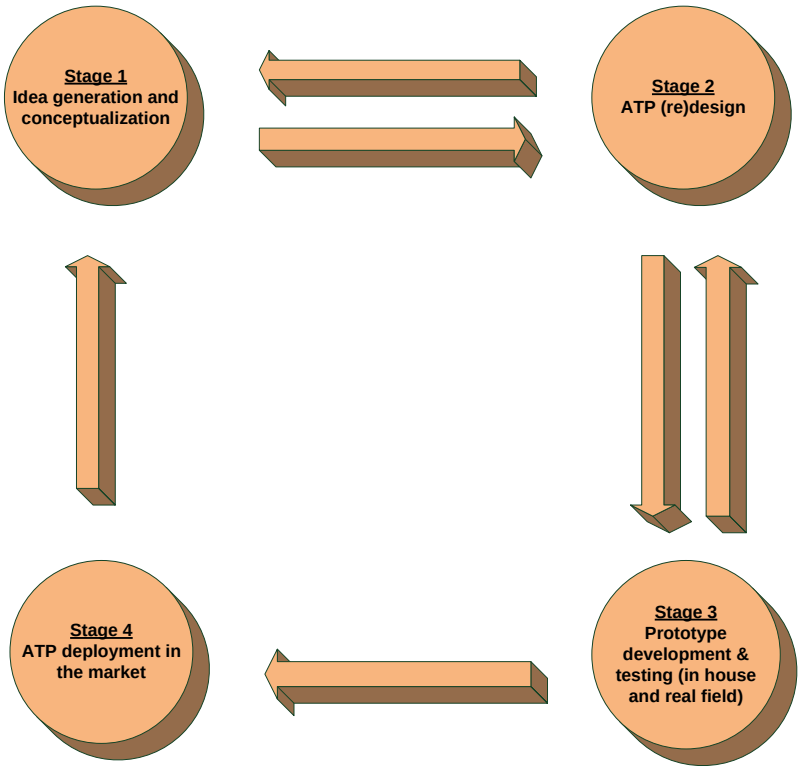

Figure 14: Scenario 1: ATP new to the market

6.5.2 Scenario 2: major upgrade/improvement of an existing ATP

The second scenario in ATP development is "a major upgrade/improvement of an existing ATP". In this scenario the development process is an ongoing iteration process mainly between the design and prototype development, prototype testing and deployment stage. This iterative process between the three stages is illustrated below in Figure 15. In this scenario the users as well as the various types of stakeholders can be engaged in the different stages depending on the chosen route as discussed in section 6.6.

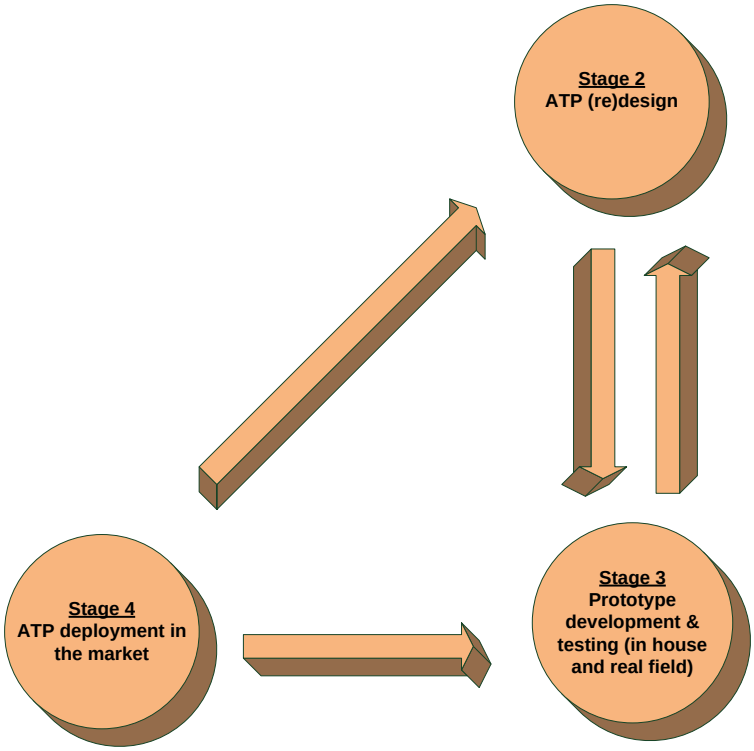

Figure 15: Scenario 2: Major upgrading/improvement of an existing ATP

6.5.3 Scenario 3: redesign/customization of an ATP prototype

The third scenario in ATP development is "redesigning/customization of an ATP prototype". In this scenario the development process is an ongoing iteration process mainly between the design and prototype development and prototype testing stage. This iterative process between the two stages is illustrated below in Figure 16. In addition sometimes obtaining the users' opinions via the idea generation and conceptualization stage can be useful in this scenario. This is optional and dependent on the type of project or the information that is required from the end-users at a particular moment. Therefore, it is not always required to apply this extra step. In this scenario the users as well as the various types of stakeholders can be engaged in the different stages depending on the chosen route as discussed in section 6.6.

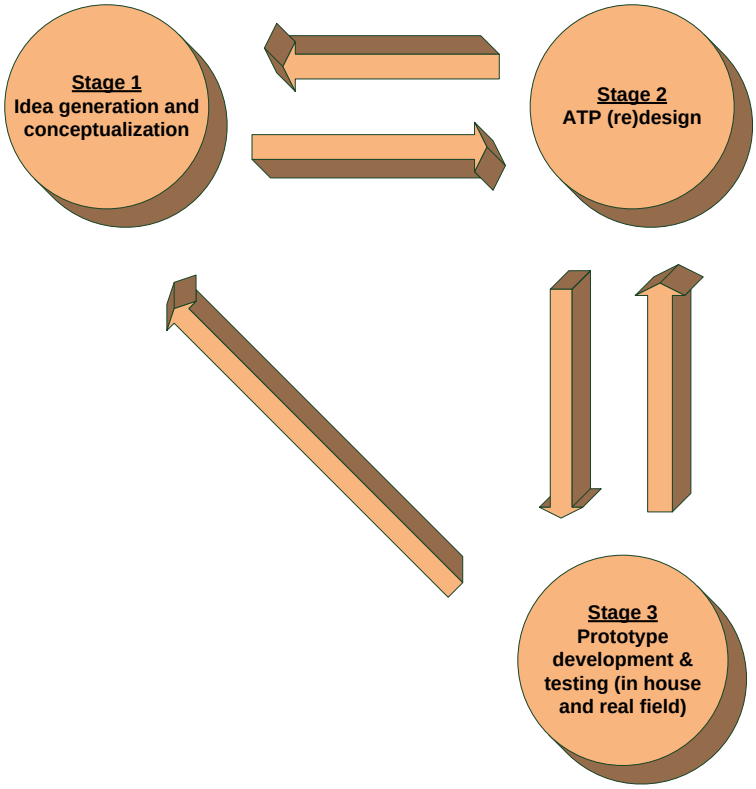

Figure 16: Scenario 3: Redesign/customization of an ATP prototype

6.5.4 Scenario 4: transforming mainstream technology into an ATP

The ATP market is smaller comparing to other markets of mainstream products. This can lead to that manufacturers do not choose to develop ATPs from scratch rather they are more likely willing to use mainstream technology for developing ATPs to remain profitable. In addition due to the factors such as developing new product requires a lot of research which is costly and time consuming, we believe cost savings and shorter research times can be achieved by looking into mainstream technologies when a manufacturer decides to develop an ATP. Therefore, we believe that a fourth scenario should be added to the ATP co-creation framework which describes "transforming mainstream technology into an ATP". In this scenario the development process is an ongoing iteration process starting from conceptualization stage through to the market deployment of the ATP. This iterative process between the four stages is illustrated below in Figure 17. In this scenario both the users as well as the various types of stakeholders can be engaged in the different stages depending on the chosen route as discussed in section 6.6.

The reason why we have chosen to add the idea generation and conceptualization stage to this scenario is because, users and stakeholders might have interesting ideas that they want to share regarding using an existing mainstream technology which was originally developed and being used for other purposes than as an ATP. The reason why Figure 17 below looks the same as Figure 14 is because, the development process of "an ATP new to the market" and "transforming mainstream technology into an ATP" is actually a similar process because in this scenario it is also required to start with stage 1 to come up with ideas about what is possible with a mainstream product that is being transformed into an ATP. Then in stage 2 determining what should be changed on the existing design of the product. After the design process is completed built the prototype in stage 3 and test it to determine if it fulfills the user requirements. And finally release it to the market.

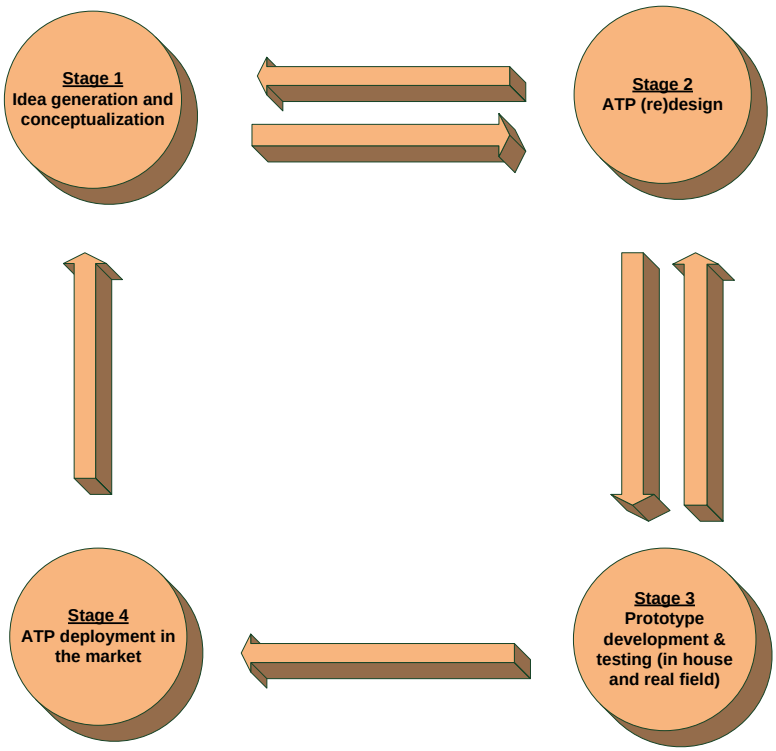

Figure 17: Scenario 4: transforming mainstream technology into an ATP

6.6 The different routes in ATP development

In the framework, we identify the users and the various types of relevant stakeholders in ATP development. In addition we divide the stakeholders into two

groups and we name them the non-professional and professional stakeholders as we discussed in section 4.3. From the users' and stakeholders' perspectives there are a number of different 'routes' in ATP development. In our theoretical framework, we suggest seven routes which ATP developers can choose from as shown in Table 16 below. They can choose to follow one route e.g. following the end-users route, the non-professional stakeholders route or the professional stakeholders route. Other available option include following a combination of routes e.g. the end-users and non-professional stakeholders routes together, end-users and professional stakeholders together or non-professional stakeholder and professional stakeholders together. ATP developers may even choose to follow end-users, non-professional stakeholders and professional stakeholders routes together in the same project. Their choice depends on what type of ATP they are planning to develop and what input in that particular project is required from the users and/or stakeholders.

Each of the routes include four stages i.e. idea generation and conceptualization, ATP design and prototype development, prototype testing and market deployment. These four stages of users' and stakeholders' engagement are proposed for the development of an ATP new to the market which we discussed in section 6.5.1. On the other hand upgrading/improvement of an existing ATP which we discussed in section 6.5.2 involves three stages for users' and stakeholders' engagement including ATP design and prototype development, prototype testing and deployment to the market. When we look at redesign/customization of an ATP which we discussed in section 6.5.3 then we see that It requires iterative user involvement in two stages i.e. design and prototype development & testing stage. In addition sometimes obtaining the users' opinions via the idea generation and conceptualization stage can be useful in the last mentioned scenario. This is depending on the type and the scale of the project. Furthermore the fourth route which we discussed in section 6.5.4 includes idea generation and conceptualization, ATP design and prototype development, prototype testing and market deployment stages for engaging the users' and stakeholders'.

Besides the above proposed seven routes in ATP development there are also other routes that ATP developers can follow including development by charitable organizations, researchers (academic projects), students, collaboration between industry and universities, one off developments for a particular end-user by researchers or organizations etc. However, these routes are out of the scope of this study, since we in this study only focus on the users' and stakeholders perspectives in ATP development. Therefore, we do not discuss them in detail. The seven routes mentioned above are discussed in detail in the next sections.

6.6.1 The end-users route

We propose ATP developers to follow the end-users route for engaging the end-users i.e. blind and partially sighted people in the iterative process of the various stages of ATP development depending on the ATP development scenarios as described in section 6.5. The end-users route is applicable for all the four scenarios. An ATP used by the end-users can be either simple and less complex as well as complex and innovative. We believe that the end-users can be engaged in the innovation process of both types of ATP development. An example of a simple ATP could be for instance magnifying software for partially sighted people and an example of a complex ATP could be for instance specific (artificial intelligence) AI software for a smartphone or wearable device which a blind person can use to perceive and/or recognize objects in the environment.

6.6.2 The non-professional stakeholders route

We propose ATP developers to follow the non-professional stakeholders route for engaging the non-professional stakeholders i.e. family members, acquaintances, friends, colleagues, caregivers etc. in the iterative process of the various stages of ATP development depending on the ATP development scenarios as described in section 6.5. It is important that the users adopt the newly developed ATP because they will be the ultimate users of that ATP. Therefore, besides the non-professional stakeholders mentioned here, it is also useful to engage the end-users in the testing and deployment stage of ATP development to ensure the ATP fits the

user needs/requirement and that it is working properly. The non-professional stakeholders' route is applicable for all the four scenarios. As we discussed in section 6.6.1 an ATP used by the end-users can be either simple and less complex as well as complex and innovative. We believe that the non-professional stakeholders can be engaged in the innovation process of both types of ATP development.

6.6.3 The professional stakeholders route

We propose ATP developers to follow the professional stakeholders route for engaging the professional stakeholders i.e. ophthalmologists, opticians, technical ophthalmic assistants, optometrists etc. in the iterative process of the various stages of ATP development depending on the ATP development scenarios as described in section 6.5. As we mentioned in the previous section about engaging the non-professional stakeholders in the innovation process, it is important that the users adopt the newly developed ATP because they will be the ultimate users of that ATP. Therefore, besides the professional stakeholders mentioned here, it is also useful to engage the end-users in the testing and deployment stage of ATP development to ensure the ATP fits the user needs/requirement and that it is working properly. The professional stakeholders' route is applicable for all the above discussed four scenarios. As we discussed in section 6.6.1 an ATP used by the end-users can be either simple and less complex as well as complex and innovative. We believe that the professional stakeholders can be engaged in the innovation process of both types of ATP development.

6.6.4 Combinations of routes

We propose ATP developers to follow multiple routes in a project for engaging the end-users, non-professional stakeholders and the professional stakeholders in the iterative process of the various stages of ATP development depending on the ATP development scenarios as described in section 6.5. It is even possible to engage users, non-professional and professional stakeholders at the same time in a particular project. The possible options for the different routes that can be used at the same time in a project are illustrated in Table 16 below.

ROUTE	EU	NPS	PS	In addition engaging end-users in stage 3 and stage 4 of the ATPDP	Description
EU	x				Option 1: following the EU route
NPS		x		x	Option 2: following the NPS route
PS			x	x	Option 3: following the PS route
EU	x	x			Option 4: following the EU and NPS route
EU	x		x		Option 5: following the EU and PS route
NPS		x	x	x	Option 6: following the NPS and PS route
EU	x	x	x		Option 7 following the EU, NPS and PS route

- EU= End-Users route
- NPS= Non-Professional Stakeholders route
- PS= Professional Stakeholders route

Table 16: Combinations of routes

As we mentioned in previous sections, it is important that the users adopt the newly developed ATP because, they will be the ones who will use that ATP to eliminate a problem related to his/her handicap. As shown in Table 16, we recommend ATP developers to engage the end-users in the testing and deployment stage of ATP development when they choose to use one of the options i.e. option 2, option 3, or option 6 to ensure the ATP fits the user needs/requirement and that it is working properly. The remaining four options i.e. option 1, option 4, option 5 and option 7 are excluded from this because, and in those routes the end-users are already engaged in the whole innovation process. All the different routes shown in this Table are applicable for all the four scenarios. As we discussed in section 6.6.1, an ATP used by the end-users can be either simple and less complex as well as complex and innovative. We believe that all the different routes can be useful in the innovation process of both types of ATP development. The first three options shown in the Table were already discussed in the previous sub-sections. However, to show a complete overview of the available options in one Table, we have also added these three options in this Table.

Chapter 7: Discussion

Various conventional approaches have been applied in mainstream, medical device and assistive technology product development including expert driven design and User Centered Design. Expert driven design is considered as a "designing for people" approach and User Centered Design is considered as a "designing with people" approach. In most cases manufacturers have chosen to use expert driven approaches in ATP development. Although this has been slowly changing from expert driven to User Centered Design approaches, end-user involvement in ATP development has been very modest. limited user involvement could be due to factors such as (1) a lack of funds/cost constraints, (2) management pressure, or (3) lack of time that manufacturers have, because of they are operating in a competitive market (Syed Ghulam Sarwar Shah I. R., 2007), (Hersh, 2010), (Fernandes, 2010). Another reason for limited user involvement could be personal limitations of users' i.e. cognitive, physical, or informational problems that may hinder meaningfully participation in ATP development (Syed Ghulam Sarwar Shah I. R., 2007). However, there is often a willingness among manufacturers to hear/receive input i.e. creative ideas of the end-users or stakeholders in the ATP development process but, the absence of an effective framework can be another limitation in those situations. In this study we have proposed a generic theoretical framework for direct involvement of both ATP users and relevant stakeholders in the innovation process.

In User Centered Design the end-user is involved in the design process by using conventional methods i.e. interview, surveys etc. IDEO's approach on User Centered Design is what they call Human Centered Design that focuses on aspects such as user needs determined by user behavior, feasibility; what is technically and organizationally feasible? And viability; what can be financially/economically viable? IDEO developed a toolkit consisting of various methods that designers can use to capture user needs/behavior for creating more appropriate solutions for the end-users. Over the years there has been a shift from User Centered Design to Participatory Design. Participatory Design is considered a subdivision of Human/User

Centered Design, and is seen as a new attitude towards people and the belief that whether an individual is an expert/designer, or not he/she can contribute to design ideation when provided with the right tools to express their ideas. We looked whether IDEOs toolkit could be used in ATP development. Although IDEOs HCD approach might be a suitable approach for developing ATPs for visually impaired people, we could not find evidence in literature or practice showing the use of IDEOs toolkit in creating an ATP for visually impaired people. On the other hand evidence showed that the co-creation approach has been successfully applied for developing a product for blind children.

Co-creation is the new trend in Participatory Design. It is an important aspect of Participatory Design as a new way to give users agency to advocate, act, and create their own desirable situations. Co-creation is considered as a "designing by people" approach. The authors in the paper "The vital role of user involvement in the development process of an assistive device" indicate that professionals are especially concerned with health and safety as well as cost issues while users are willing to take more risks and are far more interested in function and independence when designing ATPs (Ruth E Mayagoitia). Therefore, we believe that the key formula for a successful ATP development for visually impaired people can be realized through combining user needs/experiences and the expertise of ATP designers. A co-creation approach can be applied to bring the users and the experts on the same level in the innovation process. We believe that the co-creation approach should be used as the main approach when developing ATPs for visually impaired people. In addition case study shows that especially a co-creation approach is very suitable for designing for people with visual disabilities because, it helps developers and designers to envision how blind/visually impaired people experience their world. The case study findings were a reference for us to justify our choice of incorporating the co-creation approach in the proposed theoretical framework, for engaging visually impaired people and the various types of stakeholders in the ATPDP as shown in Figure 13. In the proposed framework, we suggest various methods/tools that can support co-creation activities for co-creation of ATPs with the end-users and the different relevant stakeholders. The co-creation approach forms the basis of the proposed

framework. End-users and the stakeholders collaborate on each stage of the development process starting with idea generation, design, prototyping and testing and market deployment. The framework promotes engaging the end-users in the whole innovation process because, the people that are using ATPs, are usually the best experts on their own lives.

The co-creation approach is flexible and it can be adapted to meet the needs of both the users as well as the various types of stakeholders that are involved in the innovation process and it can be applied in different situations. The co-creation approach not only facilitates bringing the users, stakeholders and experts physically around the table but, it is also a very useful approach to bring them mentally together. It is not always required that users and stakeholders come together around the same table but, the collaboration/participation can also take place in online co-creation sessions. Therefore, we believe that promoting online participation besides physical presence in co-creation sessions can be very effective. In addition we believe that visually impaired people can convey their creative ideas better when they are in a (known) environment where they feel comfortable. However by suggesting this we do not mean to drop or replace onsite co-creation for online co-creation sessions rather, we suggest to combine online and onsite co-creation sessions. Combining online and onsite co-creation session can create/promote the concept of "Design Anytime, Anywhere, And Anyplace".

We recognize that ATPs differ from each other depending on the complexity of the technology involved, type of the intended users i.e. blind or partially sighted people, the different stakeholders i.e. both professionals as well as non-professional stakeholders, the environment and the context of the use of the ATP by the end-user. The type of the intended user and selecting the relevant stakeholders per project is a critical issue. Therefore, in this framework we have suggested various routes that ATP designers can follow as discussed in section 6.6. In the framework, we have proposed that if the ATP being developed is a simple or a complex ATP, ATP developers have the choice to follow one of the proposed seven routes. Their choice depends on what type of ATP they are planning to develop and what input in that

particular project is required from the users and/or stakeholders. However, if ATP developers choose a route which end-users are not part of that route, we recommend ATP developers to involve the end-users at least in stage 3 and stage 4 of the innovation process to assess and evaluate the ATP performance, since the end-users know their needs better than anyone else. Furthermore, we assume that end-users might already have used a similar ATP at some point in their lives which means they have some experience and knowledge of the limitations of using such an ATP. In those situations, the end-users can play an important role in (re)designing or upgrading of existing ATPs as well as developing ATPs from scratch that will serve a similar purpose. On the other hand when transforming a mainstream technology product into an ATP, involving different stakeholders in the innovation process who already may have used that mainstream product for other purposes can also play an important role because, they may have experience in using that product which means they may come up with suggestions regarding what is possible with that product. It is also possible that non-professional and professional stakeholders can convey some of the needs/requirements of the end-users, which they have come to know often through contact/ (close) relationship with the end-users as discussed in section 4.3. ATP developers can therefore consider involving the different stakeholders in the innovation process through one of the suggested routes where stakeholders are part of a route, to get their perspectives about the ATP. Furthermore, the ATP market is smaller comparing to other markets of mainstream products. This can lead to that manufacturers do not choose to develop ATPs from scratch, instead they might prefer to use mainstream technology for developing ATPs due to factors such as developing new product requires a lot of research which is costly and time consuming. We believe cost savings and shorter research times can be achieved by looking into mainstream technologies when a manufacturer decides to develop an ATP. Therefore, we believe that the scenario "transforming mainstream technology products into assistive technology products" is essential and a relevant scenario in the proposed framework.

It is good to know that end-users are no experts/designers. Therefore, they may not possess sufficient technical knowledge and understanding about (complex)

ATPs to be able to fully give significant assessment about those products. ATP developers should not expect end-users to solve major technical problems. Therefore, Lichter suggests in his work that the involvement of the end-users should be mainly for the purpose of identifying and clarifying their requirements and the vital features of the products for them (Lichter H, 1994) and Buhler suggests involving the end-users at testing stages in the innovation process (Buhler, 1996). The proposed framework does not offer solutions. Instead, it offers methods, tools, tips, and to guide ATP designers through a process that gives voice to end-users and relevant stakeholders in ATP development. It allows their desires to guide the creation and implementation of more appropriate and acceptable solutions for the end-users. We do not prescribe specific methods/tools for involving the end-users and stakeholders at any point in the ATP development process because, we believe that the selection of those particular methods/tools depends upon the resources, both money and time, and expertise available to the ATP developer. We leave the choice to ATP designer to decide themselves whether to use any particular method/tool, considering the costs and resources available together with the type of data they require from the end-users and/or stakeholders and the quality of the input/information obtainable through the selected method(s) and/or tool(s).

Chapter 8: Conclusion

Development of appropriate and acceptable ATPs for visually impaired people requires the involvement of the end-users, non-professional and professional stakeholders. Evidence shows that end-users can abandon an ATP that does not fulfill their personal expectations, although the designers and experts may consider those end-user requirements are met. ATP developers need to recognize the potential creative and valuable input of the different parties involved in the innovation process and therefore, involve end-users and the different stakeholders relevant in ATP development directly in the development process. Case study showed that using a co-creation approach can result in the creation of appropriate and acceptable products for visually impaired people because it is a very suitable approach for engaging especially special types of end-users in the innovation process. Moreover, applying the co-creation approach may also result in shorter development time of projects because, the user needs/requirements are already being taken account during the development process. In order to ensure that the end-users adopt the specified co-creation methods/tools, it is required that the facilitator(s) consult with the end-users and professionals i.e. physical therapists, exercise specialists, teachers etc. to get insight in what should be adapted to a standard co-creation method/tool to make it suitable for the special target group. This is very important because, the case study showed that the successful participation of the blind children was achieved through adapting those standard co-creation methods to ensure that those methods were meaningful for the blind children. Every co-creation process is different depending on the project and participating people in that project. In this study we showed what ATP developers should bear in mind when they decide to use a co-creation approach for developing an ATP. The proposed theoretical framework is a step forward in helping ATP developers plan and make decisions about users' and different stakeholders' involvement at different stages of the ATP development process.

8.1 Evaluation of the theoretical framework

The proposed theoretical framework can be seen as a practical guide for the creation and assessment of ATPs. In the framework, we have incorporated a co-creation approach consisting of various methods/tools that can support co-creation activities. The suggested methods/tools are currently known in the literature which already has been successfully applied in different projects. ATP designers can choose to use the methods/tools that are relevant in a particular project depending on different factors as discussed earlier. The conceptual framework is generic and therefore it can also be applied in other types of product development than ATP development. However, the framework then needs to be partly modified e.g. the users and the stakeholders part needs to be modified by specifying the right users and stakeholders that is relevant in that particular project. Furthermore, in the future the framework can be extended with new co-creation methods/tools or irrelevant ones may be removed depending on the available methods/tools at that moment. The other parts of the framework can remain unchanged unless the different stages in product design do not dramatically change. This conceptual framework can support ATP manufacturers, who may have limited expertise with end-users engagement in the innovation process, and developing decision-making protocols regarding users' and relevant stakeholders' involvement in the ATPDP.

8.2 limitations of the theoretical framework

In section 5.5, we discussed the limitations of the case study. In this section, we discuss the limitations of the proposed conceptual framework. These limitations include (1) the need for its validation which we discuss in section 8.3. This limitation can be undertaken by collaboration with organizations that are designing ATPs for visually impaired people. And (2) the generality in its description. However, this is done purposely to provide a generic framework to present it as an easily understandable approach for decision makers in ATP manufacturers.

8.3 Validity

The proposed conceptual framework can be partly validated. Firstly the co-creation approach that we have incorporated in the framework is a known approach in the literature. In addition the decision to use the co-creation approach instead of conventional approaches can be validated by looking at the positive results of using the co-creation approach in the development of the WII game for visually impaired people. Secondly the different stages of product development process which is part of the proposed framework is also known in the literature. Furthermore, to identify the various types of stakeholders that may provide valuable/useful input during the development process is done through conducting informal interviews with the professionals at organizations that provide services for visually impaired people. Moreover, we looked at the different functions in those organizations to find relevant professionals who may be involved in ATP development. One of the things that is not validated is the fourth scenario which we have defined. To validate this scenario further research needs to be done to discover whether this fourth scenario can be applied and/or is effective in real life projects. Furthermore, to validate the effectiveness of the suggested co-creation methods/tools for engaging end-users and the different stakeholders in ATP development process, the framework needs to be applied in different real life projects.

8.4 Future research

In this exploratory research, we have systematically defined and explored a wide spectrum of things related to users and different stakeholders' engagement in ATP development and we used facts and arguments to explain our view on each particular aspect. This work can be seen as a basis for further research in the area of engaging special types of end-users and other relevant professionals in ATP development. Qualitative as well as quantitative data can be collected by applying the proposed framework in multiple projects related to ATP development. Below, we have listed a number of recommendations regarding future research.

Future research can be done to explore:

- We do not have practical evidence showing the challenges of using a co-creation approach for engaging visually impaired people in the ATP development process. Although case study findings showed some challenges of involving visually impaired children in the innovation process, these challenges cannot be related to ATP development because, an ATP is a different product category than a game which was the subject in the case study and those challenges were related to children and not adults. Therefore, future research is required to identify (potential) challenges of using a co-creation approach in the ATPDP.
- In the proposed framework, we suggest to involve both end-users (visually impaired people) and stakeholders (people with normal vision) at the same time in the innovation process. However, we do not know what the effect is of the collaboration of these types of people. Future research is required to identify the effectiveness of this collaboration.
- Theoretically the proposed framework is validated because we incorporated existing co-creation methods in the framework and used the assistive technology development lifecycle as the basis of the framework. However, the effectiveness of this framework needs to be validated in practice. Therefore, further research is required to validate the framework in practice by applying it in different projects for developing ATPs.
- Doing research is costly and time consuming. Evidence shows that involving the end-users in product development can incur addition costs. Future research is required to measure the economic value of using the proposed theoretical framework in ATP development.
- In the proposed framework, we identify some routes that ATP designers can follow. These routes are related to the users' and stakeholders' perspectives. The framework can be extended by adding new routes to cover other perspectives including the regulators' and manufacturers' perspectives or other perspectives that may exist in product development. We suggest this

because the co-creation approach is very broad and it can cover multiple perspectives in product development.

- We suggested various standard co-creation methods/tools that can be used to engage end-users in the innovation process and we recommended that ATP designers need to adapt these methods in consultation with the end-users and the professionals to ensure that those methods are meaningful and suitable for visually impaired people. However, perhaps specific co-creation methods/tools can be created so that these methods/tools can be used out of the box by ATP designers. We suggested standard co-creation methods because we have to keep in mind that the stakeholders with normal vision are also involved in the innovation process at the same time with visually impaired end-users. Future research is required to explore to what extent it is possible to develop such a toolkit consisting of specific co-creation methods/tools taking in account the different visual acuity and different needs of these special types of users.
- In the proposed framework, we suggest to use the co-creation approach to engage the users and different stakeholders in the innovation process. Although we suggest some tools which can monitor active users and their activities, we do not identify metrics to measure user and stakeholder engagement in the innovation process. Therefore, further research is required to identify those engagement metrics.
- We did not use existing modeling languages to develop the conceptual framework because, in this study we were more interested in to what extent the co-creation approach is a suitable approach for engaging special types of users in the ATPDP and how it can be applied in the existing ATPDP. Future research is required to explore to what extent it is possible to develop a similar framework by using existing modeling languages to increase (theoretical) validity.

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Glossary of terms

AP	Assistive Product
APs	Assistive Products
AT	Assistive Technology
ATP	Assistive technology Product
ATPs	Assistive technology Products
ATPD	Assistive Technology Design/Development
ATPDP	Assistive Technology Product Development Process
CEO	Chief Executive Officer
GAMBAS	GAMes for the blind and sighted
GPS	Global Positioning System
HCD	Human-Centered Design
NIH	National Eye Institute
IT	Information Technologies
OCR	Optical Character Recognition
PD	Participatory Design
PDA	Personal Digital Assistant
R&D	Research & Development
TNO	Toegepast-Natuurwetenschappelijk Onderzoek (a research organization in the Netherlands)
UCD	User-Centered Design
WHO	World Health Organization

Appendix A: Description of the methods/tools presented in the framework

In the table below a list of the methods/tools presented in the proposed conceptual framework is provided. In addition a short description of each item is given.

Description of the presented methods/tools in the framework	
Method/tool	Clustering
Short description	It is a way of generating ideas by mapping and organizing them as they occur.
Reference	http://www.winona.edu/writingcenter/invent.htm
Method/tool	Listing
Short description	It is a way to generate ideas and sort them.
Reference	http://www.winona.edu/writingcenter/invent.htm
Method/tool	Cubing
Short description	Is useful for probing a topic from six different perspectives.
Reference	http://www.winona.edu/writingcenter/invent.htm
Method/tool	Dramatizing
Short description	It allows you to think about human behavior in dramatic terms. Drama has action, actors, setting, motives, and methods, and each of these points provides a different perspective on behavior.
Reference	http://www.winona.edu/writingcenter/invent.htm
Method/tool	Free writing & looping
Short description	It generates ideas by "freeing" the link between your brain and your pen. The objective is to write as quickly and as freely as you can.
Reference	http://www.winona.edu/writingcenter/invent.htm
Method/tool	Questioning
Short description	Asking questions about a subject is a way to learn about it and decide what to write.
Reference	http://www.winona.edu/writingcenter/invent.htm

Method/tool	Mindmapping
Short description	Graphical technique for visualizing connections between several ideas or pieces of information. Each idea or fact is written down and then linked by lines or curves to its major or minor (or following or previous) idea or fact,
Reference	http://www.businessdictionary.com/definition/mind-mapping.html
Method/tool	Group mindmapping
Short description	Mind Maps are vehicles for effective group working. There are several different ways in which Mind Maps can be used by groups.
Reference	Liliane Kuiper-Hoyng, Rob Willems, Sven Schultz. Involving blind children in the co-design of a Wii game. (2008) http://www.mind-mapping.co.uk/group-mind-mapping.htm
Method/tool	Social Media
Short description	Social media is the collective of online communications channels dedicated to community-based input, interaction, content-sharing and collaboration. Examples of different types of social media include blogs, microblogs, social networking, social bookmarking, social curation and wikis.
Reference	Andreas M. Kaplan, Michael Haenlein, Users of the world, unite! The challenges and opportunities of Social Media (2009) http://whatis.techtarget.com/definition/social-media
Methods/tool	Empathy tools
Short description	The designer uses a simulation device to gain first-hand insights into particular impairments or disabilities, for example clouded glasses to simulate sight loss.
Reference	http://designingwithpeople.rca.ac.uk/methods/empathy-tool
Method/tool	Virtual workspace
Short description	It is not located in a physical space. It is usually in a network of several workplaces connected via Internet without geographic boundaries.
Reference	http://www.businessedge.ca/archives/article.cfm/team-building-key-for-virtual-workplace-10076 http://dl.acm.org/citation.cfm?id=968464.968467
Methods/tool	User forum
Short description	It is an interactive session between designers and users where all attendees contribute to the dialogue and express their opinion.

Reference	http://designingwithpeople.rca.ac.uk/methods/user-forum
Method/tool	Affinity diagrams
Short description	It is a creative process used for gathering and organizing large amounts of data, ideas and insights. In a session each participant thinks of ideas and writes them on small pieces of paper. The result is a visual representation describing the exploration of design suggestions.
Reference	Steven Bonacorsi, What is an Affinity Diagram? (2008)
Method/tool	(Online) whiteboard
Short description	An online Whiteboard lets you use your computer, tablet or smartphone to easily draw sketches, collaborate with others simultaneously or separately and share it with others. In addition a regular whiteboard can also be used when organizing onsite co-creation sessions when people physically attend the sessions.
Reference	http://www.scriblink.com/ http://www.scriblink.com/
Method/tool	Web-based office suite
Short description	Web based office suite let you create, edit and share your Excel, Word and PowerPoint files from any browser. You can share and simultaneously work on your documents with co-workers. No need to merge different versions later.
Reference	http://office.microsoft.com/en-us/web-apps/ http://www.thinkfree.com/main.jsp docs.google.com
Method/tool	Wiki's
Short description	A wiki allows a visitor to the Web site to edit the content of the site from their own computer. Visitors can also create new content and change the organization of existing content.
Reference	http://searchsoa.techtarget.com/definition/wiki
Method/tool	Web forums
Short description	Web forums are online communities that focus on a shared interest or experience. It is a website or section of a website that allows visitors to communicate with each other by posting messages.
Reference	http://designingwithpeople.rca.ac.uk/methods/web-forum http://www.techterms.com/definition/web_forum

Method/tool	Application sharing tools
Short description	Application Sharing allows a moderator or participant to share any application, a specific region of the desktop, or the entire desktop with other attendees. The host of the application can grant remote control of his or her shared application(s) to others.
Reference	http://www.elluminate.com/downloads/support/docs/8.0/Elluminate_Live_V8_Application_Sharing_Quick_Reference_Guide.pdf
Method/tool	Story telling
Short description	It supports the exploration of the product idea. Through the use of simple words, the teller will illustrate the solution as it is a story.
Reference	Kevin Brooks, Whitney Quesenbery, "Storytelling for User Experience Design, Rosenfeld Media, (2009)
Method/tool	Chatting tools
Short description	On the Internet, chatting is talking to other people who are using the Internet at the same time you are. Chatting tools support talking to other people on the internet.
Reference	http://searchsoa.techtarget.com/definition/chatting
Method/tool	Living Labs
Short description	Living Labs is defined as a forum for research and innovation applied to the development of new products, services and processes. It employs working methods to integrate people into the entire development process as users and co-creators and recognises the needs of users and the working conditions of service providers, both in their respective contexts.
Reference	Veli-Pekka Niitamo, S. K. (n.d.). State-of-the-Art and Good Practice in the Field of Living Labs. Helsinki : Helsinki School of Economics. Mats Eriksson, V.-P. N. (2005). State-of-the-art in utilizing Living Labs approach to user-centric ICT innovation. Luleå University of Technology. http://www.ami-communities.eu/drupal/node/28 http://www.lilan.org/en/Living-labs-description/
Method/tool	Experience prototype
Short description	It allows designers to show and test the solution through an active participation of the users.
Reference	Marion Buchenau, Jane Fulton Suri, Experience Prototyping, paper presented at the Symposium on Designing Interactive Systems, (2000)

Method/tool	3D environments
Short description	Often referred to as virtual reality or interactive 3D and have a figurative appearance. Much like our own world, this type of world allows interaction with other (networked) beings as well as manipulation of objects
Reference	Loeffler and Anderson, The Virtual reality casebook, (1994)
Method/tool	Group sketching
Short description	It is used during the co-design sessions in order to share the insights inside the team. The tool offers a common ground for the discussion even when the participants have different cultural and social backgrounds.
Reference	Saul Greenberg, Mark Roseman, David Webmaster, Group Sketch, (2006)
Method/tool	Storyboarding
Short description	It is the representation of use cases through a series of drawings or pictures, put together in a narrative sequence.
Reference	L. Vertelney, G. Curtis, Storyboards and Sketch Prototypes for Rapid Interface Visualisation, CHI Tutorial, (1990)
Method/tool	Lego Serious Play
Short description	The process is based on the use of common LEGO in order to envision and share thoughts inside the team.
Reference	Liliane Kuiper-Hoyng, Rob Willems, Sven Schultz. Involving blind children in the co-design of a Wii game. (2008) http://www.seriousplay.com/ http://www.springerlink.com/content/b0368p1655r23775/
Method/tool	Role play (Skits)
Short description	Some actors, the sample users or the designers themselves perform a hypothetical product experience.
Reference	Liliane Kuiper-Hoyng, Rob Willems, Sven Schultz. Involving blind children in the co-design of a Wii game, (2008) Mattias Arvola, Henrik Artman, Interaction Walkthroughs and Improvised Role Play, paper presented at DeSForM 2006, Eindhoven, (2006)
Method/tool	Design games
Short description	It enables participants to express their needs and preferences through the actions of a board game. The game can be played individually or in a group within

	a workshop setting, enabling the construction of different scenarios and design outcomes.
Reference	http://designingwithpeople.rca.ac.uk/methods/participatory-design-game Eva Brandt, Jorn Messeter, Facilitating Collaboration Through Design Games, (2004)
Method/tool	Issue cards/card sorting
Short description	Those are a physical instrument used as a peg to induce and feed interactive dynamics inside a team. This method is successfully applied in the Wii game project for blind children. A card trading game was designed. Each card had one game item on it; in writing and in Braille. The children were told to go to the other children to find out their cards. They then had to trade cards with each other until they found their preferred game characteristics.
Reference	Donna Spencer, Card Sorting. Designing Usable Categories, Rosenfeld Media. (2009) Liliane Kuiper-Hoyng, Rob Willems, Sven Schultz. Involving blind children in the co-design of a Wii game, (2008)
Method/tool	(Online) slide/video tools
Short description	It allows users to present sequences of slides or combinations of video and slides over the net. Some examples of tools that provide online slide and video sharing are; Slideshare, Youtube and other similar platforms.
Reference	http://www.slideshare.net/ www.youtube.com
Method/tool	Rough prototyping
Short description	It is a method to build prototypes using all the objects and materials available in that specific moment and location.
Reference	Liliane Kuiper-Hoyng, Rob Willems, Sven Schultz. Involving blind children in the co-design of a Wii game, (2008) How to Prototype: The Awesome Guide, by Lindsay Gordon, (2009)
Method/tool	Character profiles / Persona
Short description	It is a tool for the creation of a shared knowledge about the product users inside the team. They are developed to understand user lifestyles, aspirations and needs.
Reference	Stefan Moritz, Service Design Practical access to an evolving field (2005)

	http://designingwithpeople.rca.ac.uk/methods/persona
Method/tool	Mockup
Short description	It is a model, an illustration or a collage describing an idea.
Reference	Moritz, Stefan, Service Design. Practical Access to an Evolving Field, tesi di dottorato di ricerca in Service, (2005)
Method/tool	Constructive interaction
Short description	It is a method based on the observation of a user during his product experience.
Reference	Benedikte S. Als, Janne J. Jensen, Mikael B. Skov, Comparison of Think-aloud and Constructive Interaction in Usability Testing with Children, Proceedings of the 2005 conference on Interaction design and children, Boulder, Colorado, (2005)
Method/tool	Wizard of OZ
Short description	It is used to test a product in a detailed way by observing the interaction of a potential user with the object without revealing the evaluator's presence.
Reference	L. Molin, Wizard-of-Oz prototyping for co-operative interaction design of graphical user interfaces. In Proceedings of the Third Nordic Conference on Human-Computer interaction, Tampere, Finland, ACM Press, New York, (2004) D. Akers, Wizard of Oz for participatory design: inventing a gestural interface for 3D selection of neural pathway estimates. In CHI '06 Extended Abstracts on Human Factors in Computing Systems, Montréal, Québec, Canada, (2006)
Method/tool	Use cases
Short description	It is used in interaction design projects for the development of the interaction flows.
Reference	Nicola Morelli, Designing product/service systems. A methodological exploration. Design Issues, 18(3), 3-17, (2002) Nicola Morelli, Developing new PSS, Methodologies and Operational Tools. Journal of Cleaner Production, 14(17), 1495-1501, (2006)
Method/tool	Usability testing
Short description	The evaluator asks the user to reach a sequence of tasks to test the functionality of a product. Then the results are evaluated.
Reference	Handbook of usability testing: How to plan design and conduct effective tests, (2008)
Method/tool	Task analysis grid

Short description	It is used to communicate decisions to stakeholders. It is an alternative to the standard requirements documents. The aim is to see the entire scope of the project.
Reference	http://iainstitute.org/tools/task_analysis_grid.php http://blogs.msdn.com/b/jmeier/archive/2007/02/09/task-analysis-grid-for-communicating-product-design.aspx
Method/tool	Reputation and rating tools
Short description	It allows members to rate contributions of others in the team. By doing this it allows to build reputation scores for members.
Reference	http://whatis.techtarget.com/definition/reputation-management
Method/tool	Web meeting tools
Short description	A platform aggregating a set of tools for synchronous online group interactions. These tools are ideal for meeting-oriented communities.
Reference	https://docs.google.com/document/d/1uTVa1Dsx_f9CoHGr9X50nlJazrum1KD1oCDi8lYHyaA/preview?pli=1
Method/tool	(co-creation) workshops
Short description	Users can get involved in brainstorm sessions by using co-creation workshops to generate ideas and design concepts. It is very useful when the developers of a product want to gain insights in the needs of the users.
Reference	Thorsten Roser, A. S.-V. Co-creation: New pathways to value An overview. London: LSE Enterprise Promise (2005).
Methods/tool	Pseudo-documentary
Short description	It presents a design scenario in the form of a film that has a documentary format. Real users of a future product can participate in the pseudo-documentary working as actors.
Reference	http://designingwithpeople.rca.ac.uk/methods/pseudo-documentary
Methods/tool	Lateral thinking
Short description	Designers and users list the sequence of actions in a particular process, and then play around with these by removing, reversing or distorting some of them to provoke lateral thinking.
Reference	http://designingwithpeople.rca.ac.uk/methods/lateral-thinking http://lateralaction.com/articles/lateral-thinking/

Method/tool	Poster
Short description	Through the elaboration of the Poster, the designers imagine how the new offering could be launched on the market and perceived by the consumers.
Reference	Bill Moggridge, Designing Interactions, The MIT Press, Cambridge. (2006)
Method/tool	Screencasts
Short description	Screencasts are digital video recordings that capture actions taking place on a computer desktop. Screencasts are useful for demonstrating how to use product, software applications or website features.
Reference	http://whatis.techtarget.com/definition/screencast
Method/tool	Tomorrow headlines
Short description	It is a way to visualize the idea and make it more tangible, more real and more univocally perceived among the team and the stakeholders.
Reference	IDEO, Method Cards, William Stout Architectural Books, San Francisco. (2002)
Method/tool	Q&A tools (Question and Answer tools)
Short description	Q&A tools allow participants of a project to ask questions and receive answers related to the project they are participating.
Reference	http://www.osqa.net/
Method/tool	Offering map
Short description	It is used to describe what the product offers to the end-users. The offering could be described by words or could be illustrated by images, but it can also be visualized through a graph.
Reference	http://www.bsbd.org.uk/cards/offering-map/
Method/tool	Heuristic evaluation
Short description	It is used to inspect the product usability based on a predefined set of criteria that the evaluators follow during the analysis. It gives feedback and a lot of suggestions for the improvement of the whole project.
Reference	Torre Zuk, Lothar Schlesier, Petra Neumann, Mark S. Hancock and M. Sheelagh T. Carpendale. Heuristics for Information Visualization Evaluation, (2006)
Method/tool	Cognitive walkthrough
Short description	Evaluator(s) observe a product by going through the different screens if it is a software program or they observe the product by going through the functionality

	the product offers, if it is not a software program.
Reference	Mattias Arvola, Henrik Artman, Interaction Walkthroughs and Improvised Role Play, paper presented at DeSForM 2006, Eindhoven, (2006)
Method/tool	Member directory tools
Short description	It shows information about community members. It provides an overview of the membership and other relevant information about each member. These tools are useful when information needed about the participants of the project
Reference	http://groupspaces.com/~Manage-an-Online-Group-Member-Directory
Method/tool	Polling tools
Short description	It is used to create and deploy polls i.e. closed and open ended. In addition it provides functionality to collect and analyze collected data.
Reference	http://www.questionpro.com/poll-software.html http://www.esurveyspro.com/poll-software.aspx
Method/tool	Presence indicator tools
Short description	It provides information about who is active or logged in on a computer working on a project. Using these tools provides an overview of who is actively working on a particular project.
Reference	http://office.microsoft.com/en-us/sharepoint-workspace-help/overview-of-presence-indicators-in-sharepoint-workspace-HA010292653.aspx
Method/tool	Web conferencing tools
Short description	It is used for one-to-one, one-to-many and many-to-many synchronous video conversations over the internet. Web conferences are meant to cater to small groups and keep the floor open for communication and discussion.
Reference	http://web-conferencing-services.toptenreviews.com/
Methods/tool	Day in the life
Short description	The designer follows the subject through a typical day, observing and recording events to build up a realistic picture of what actually happens. Mapping a 'Day in the Life' can illustrate graphically how time is assigned to various activities.
Reference	http://designingwithpeople.rca.ac.uk/methods/day-in-the-life Dr. Michael Arnold, The day experience method: A resource kit (2007)
Methods/tool	Design probes

Short description	A research kit is given to users to record aspects of their lives autonomously, independent of the designer. The design probe may include diaries, question cards, postcards, disposable cameras or other tools for mapping and drawing.
Reference	http://designingwithpeople.rca.ac.uk/methods/design-probe Tuuli Mattelmäki, Design probes (2003)
Methods/tool	Provocation
Short description	The designer places graphics or objects within an environment to stimulate discussion and elicit a response from the user.
Reference	http://designingwithpeople.rca.ac.uk/methods/intervention-provocation Matt Franks, Rapid Ideation & Forced Provocation

Appendix B: List of professional stakeholders

In the table below a list of relevant professional stakeholders in ATP development is provided. In addition a short description of each professional stakeholder is given i.e. what function he/she fulfills.

Description of the professional stakeholders presented in the framework	
Name	Ophthalmologists
Short description	Ophthalmologists are specially trained to provide the full spectrum of eye care, from prescribing glasses and contact lenses to complex and delicate eye surgery. Many ophthalmologists are also involved in scientific research into the causes and cures for eye diseases and vision problems.
Reference	http://www.aao.org/about/eyemds.cfm
Name	Opticians
Short description	Opticians are trained in filling prescriptions for eyeglasses and determine the proper eyeglass frames and adjust frames for proper fit. Opticians often work closely within the same practice as an optometrist or ophthalmologist, or an optician may have an independent practice.
Reference	http://www.medicinenet.com/script/main/art.asp?articlekey=22559
Name	Ophthalmic assistants
Short description	An ophthalmic assistant works with an ophthalmologist (eye doctor) to provide patient care by performing many different eye-related clinical functions. Ophthalmic assistants help ophthalmologists care for patients by performing various procedures and tests, and preparing patients to see the doctor. Their work provides the ophthalmologist with important information to help diagnose and treat patients.
Reference	http://www.healthpronet.org/ahp_month/11_07.html
Name	Optometrists
Short description	Optometrists provide primary vision care ranging from sight testing and correction to the diagnosis, treatment, and management of vision changes. An optometrist is not a medical doctor.
Reference	http://www.aapos.org/terms/conditions/132 http://www.westfriesgasthuis.nl/specialismen/Oogheelkunde/polikliniek.aspx

	informal interviews with professionals at Royal Visio
Name	Physical therapists
Short description	Physical therapists work closely with patients and provide services that help restore function, improve mobility, relieve pain, and prevent or limit permanent physical disabilities of patients with injuries, disease or disabilities.
Reference	Case study; Wii game project http://explorehealthcareers.org/en/Career/70/Physical_Therapist
Name	Teachers (in special education institutes for visually impaired people)
Short description	As regular teachers, these teachers teach visually impaired students in special education institutes. Besides the knowledge they have as a teacher, they also have knowledge related to visual impairment
Reference	Case study; Wii game project www.visio.org
Name	Orthoptists
Short description	An orthoptist is trained to evaluate disorders of vision, eye movement and eye alignment in children and adults. Orthoptists perform specialized tests to help ophthalmologists diagnose conditions such as lazy eye (amblyopia), crossed eyes (strabismus) and double vision. They may also work with ophthalmologists and patients in treating these disorders.
Reference	http://www.ohsu.edu/xd/health/services/casey-eye/your-eyes/eye-health/eye-care-specialists/ http://www.nhscareers.nhs.uk/explore-by-career/allied-health-professions/careers-in-the-allied-health-professions/orthoptist/ informal interviews with professionals at Royal Visio
Name	Exercise specialists
Short description	Exercise specialists perform all kinds of physical activity programs for (visually impaired) children whose motoric skills trail behind children with normal vision. The primary task of the exercise specialist is to organize and coordinate Physical activity programs, allowing the participants to develop their motoric skills.
Reference	Case study; Wii game project www.visio.org
Name	Occularists
Short description	An ocularist is a technician who makes, fits and maintains ophthalmic prostheses

	(artificial eyes).
Reference	http://www.ohsu.edu/xd/health/services/casey-eye/your-eyes/eye-health/eye-care-specialists/
Name	Itinerant teachers
Short description	The itinerant teacher helps pupils with visual impairment to participate to the best possible extent in the regular school system. The itinerant teacher can offer advice to teachers about arranging for a suitable learning environment and how to adapt the teaching materials. He or she not only advises about certain assistance products, but also provides support in how to use them.
Reference	http://www.visio.org/education/guidance-in-the-regular-education-system
Name	Low vision specialists
Short description	A low vision specialist examines what aid a patient can use to improve his/her functioning in daily life activities. This can range from loupes (for watching TV) to a simple hand magnifier (for example, to read the price tags in stores).
Reference	https://www.oogziekenhuis.nl/artikelen/lezen-en-zien-met-hulpmiddelen-tijdens-uw-behandeling-van-maculadegeneratie.html http://www.ikwilbeterzien.nl/ informal interviews with professionals at ERGRA
Name	Low vision therapists (occupation therapy for youth and adults)
Short description	Low vision therapists instruct individuals in the use of residual vision with optical devices, non-optical devices, and assistive technology, and help determine the need for environmental modifications in the home, workplace, or school.
Reference	http://www.visionaware.org/section.aspx?FolderID=8&SectionID=115&TopicID=518
Name	Orientation and mobility specialists (occupation therapy for youth and adults)
Short description	Orientation and Mobility specialists teach the skills and concepts that people who are blind or have low vision need in order to travel independently and safely in the home and in the community. They teach safe and independent indoor and outdoor travel skills, including the use of a long cane, electronic travel devices, public transportation, and sighted guide, human guide, and pre-cane skills.
Reference	http://www.visionaware.org/section.aspx?FolderID=8&SectionID=115&TopicID=518
Name	Vision rehabilitation therapists (occupation therapy for youth and adults)

Short description	Vision Rehabilitation therapists teach adaptive independent living skills, enabling adults who are blind or have low vision to confidently carry out a range of daily activities.
Reference	http://www.visionaware.org/section.aspx?FolderID=8&SectionID=115&TopicID=518
Name	Assistive technology specialists
Short description	Assistive technology specialists provide services that are designed to assist people with disabilities to choose, acquire, or use AT devices. They conduct research and consult the patient choosing the right assistive technology product including tools that facilitate accessibility of information i.e. magnifying and speech tools and braille.
Reference	Informal interviews with professionals at Royal Visio www.visio.org http://www.afb.org/section.aspx?FolderID=3&SectionID=44&TopicID=464&DocumentID=5747
Name	Ophthalmic technicians
Short description	Ophthalmic technicians assist with the evaluations performed by ophthalmologists or optometrists. They perform basic tests and collect data to help with diagnosis and treatment. They may also help educate patients about medical procedures, eye care or contact lenses.
Reference	http://www.ohsu.edu/xd/health/services/casey-eye/your-eyes/eye-health/eye-care-specialists/ http://www.opticiantraining.org/ophthalmic-assistant-technician-technologist-certification/
Name	Ophthalmic medical technologists
Short description	An ophthalmic technologist is qualified to perform all the tasks associated with being an ophthalmic assistant and an ophthalmic technician with the additional skills required to perform all ophthalmologic tests, assist in ophthalmic surgery, maintain ophthalmic surgical instruments, and operate highly specific equipment.
Reference	http://www.opticiantraining.org/ophthalmic-assistant-technician-technologist-certification/
Name	Psychologists
Short description	Psychologists are doctoral-trained professionals who conduct research, perform testing, and evaluate and treat a full range of emotional and psychological

	challenges.
Reference	http://www.ripsych.org/what-is-a-psychologist www.visio.org
Name	ICT trainers
Short description	An ICT trainer is responsible for training the user in the patients of software that a visually impaired person is using in daily life. This may range from training patients in activities such as computer use, use of word processor software to training the use of magnifying software.
Reference	Informal interviews with professionals at Royal Visio www.visio.org

Appendix C: List of non-professional stakeholders

In the table below a list of relevant non-professional stakeholders that can be involved in ATP development is provided.

List of non-professionals stakeholders
family members
acquaintances
friends
colleagues
caregivers
teachers (in regular schools)