MONASH University

Finding and Applying Mainstream Technology Solutions for People with Disabilities

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Abstract

According to the World Health Organization (2011) the number of people with disabilities represents approximately 15% of the world's population. Furthermore, 80% of these people are in developing countries. People with disabilities in these societies still have many problems in coping with lives of disability and being active members of their communities. Assistive technology is an important resource that helps people with disabilities be productive and participate in society. However, the high cost of assistive technology makes its solutions difficult to afford. This research aims to develop a mainstream technology selection framework (MTSF) that will help detect an individual's abilities and match these abilities with the mainstream technology features to achieve the individual's goal. The MTSF is based on activity theory and includes four instruments - assessment of needs and abilities (Interview 1), a decision tool, a search tool, and evaluation of technology effectiveness (Interview 2). A qualitative approach is used with the case study method to apply and evaluate the MTSF. Eight individuals with physical disabilities, three rehabilitation therapists, and one occupational therapist participated in this research. Semi-structured, open-ended interview questions were used to collect data. Grounded theory was used to analyse the collected data. The findings showed that the MTSF could bridge the gap created by the lack of a specialist tool for selecting effective mainstream technologies for people with disabilities. Moreover, the MTSF can be used by novice specialists who lack knowledge of the important factors that affect the selection of the effective technologies. The findings regarding the value of the recommended technologies provide promising results towards using mainstream technologies as effective alternatives to the traditional assistive technologies. Finally, an evaluation of the MTSF was conducted by the therapists. The findings regarding the effectiveness and comprehensiveness of the MTSF support that the systematic approach, which has been used to apply the MTSF, increased its effectiveness and the usefulness. Moreover, the systematic approach assisted the therapist in detecting issues that needed further consideration and support to achieve better technology solutions for people with disabilities.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Chapter 1

Introduction

1.1 Introduction

According to the World Health Organization (WHO) (2011b) the number of people with disabilities represents approximately 15% of the world's population. Furthermore, 80% of these people are in developing countries. People with disabilities in these societies still have many problems in coping with a life of disability and being active members of their communities. Assistive technology (AT) is an important resource that helps people with disabilities be productive and participate in society. However, the high cost of assistive technology makes its solutions difficult to afford.

Although assistive technologies play a crucial role in improving the quality of life of people with disabilities (Efthimiou et al. 1981; Anttila et al. 2012; Londral et al. 2015), there is a lack of research on how to select an appropriate technology for a person with disability. This lack appears in both practical and theoretical aspects. In terms of the theoretical aspect, there is no conceptual framework that presents the factors that influence the selection of the assistive technology. In terms of the practical aspect, there is no research on the use of technologies for people with disabilities in developing countries.

Furthermore, even with much research on low-cost technologies attempting to overcome the cost barrier of assistive technologies (Azmi et al. 2009; Borg and Östergren 2015), there is a lack of evaluation of the effectiveness of low-cost technologies (e.g. mainstream technologies) for the people with disabilities.

This research addresses these three gaps by developing a framework for selecting mainstream technologies for people with physical disabilities, then applying this framework in Saudi Arabia as an example of the developing countries.

This chapter starts by presenting problem of the research, followed by the motivation and aim. Next, the research questions are introduced, followed by the process undertaken to answer these questions. Then, the context of the research is established including the adopted model of disability and technologies. The chapter presents the importance of technologies for people with disabilities. Finally, the theoretical and practical contributions are introduced followed by the scope and structure of the research.

1.2 Research motivation and aim

Practitioners who are responsible of recommending assistive technologies for people with disabilities find that the process of selecting an appropriate assistive technology is difficult. The reason is the diversity of each person's requirements and the wide range of commercial assistive technologies that are available (Davies et al. 2010).

Most of the available models and frameworks for selecting assistive technologies for people with disabilities are not specifically targeted. They are instead adapted from occupational therapy (Friederich et al. 2010).

In addition, most of the current models and frameworks for the purpose improving the quality of life for people with disabilities are lacking focus on the aspect of the technology features that can provide adequate properties to meet the needs of people with disabilities (Pousada et al. 2014).

Furthermore, previous research focused on the assistive technologies which are specifically designed for people with disabilities, more than mainstream or low-cost technologies which are generally available. However, more research is needed on the use of mainstream or low-cost technologies, especially for people with disabilities in developing countries where there is a lack of financial resources for them (Borg et al. 2011; Borg & Östergren 2015). Even though there have been several attempts to use mainstream technologies for people with disabilities (Sesto et al. 2008; Standen et al. 2011), there is still insufficient evaluation of the effectiveness of the mainstream technologies for people with disabilities in practice.

Most of research on assistive technology has been conducted in a western context. There is an obvious lack of research on assistive technologies for people with disabilities in developing countries (Borg et al. 2011). Moreover, only 5-15% of the people with disabilities in developing countries who need assistive technologies have access to them, because they are expensive or unavailable (WHO 2015). For this reason, providing cheaper alternatives is a high priority.

Therefore, the researcher decided to find cases in a developing country such as Saudi Arabia. The process of finding cases in Saudi Arabia was not easy, though it was easier than Australia for many reasons. First, the low level of services offered to people with disabilities in Saudi Arabia, whether from private or governmental centres, makes it easier to find people who need to use technology to increase their quality of life. Second, technologies such as smart phones and tablets are not widely used in the manner of assistive tools. Finally, the awareness level of the benefits of the technologies needs to increase, both in general and especially for people with disabilities. The situations of the assistive technologies generally in developing countries and specifically in Saudi Arabia are further explained in the literature chapter.

Consequently, there is a need for this research to fill the theoretical and practical gaps that were stated earlier. In terms of the theoretical gap, this research develops a conceptual framework including the factors that influence the selection of the appropriate mainstream technologies for people with physical disabilities. In terms of the practical gap, this research develops a framework for a selection process of the appropriate mainstream technology and applies this framework in a Saudi context.

Besides the theoretical and practical motivation, there is a personal motivation which encouraged the undertaking of this research. Seeing my younger cousin who has Down's syndrome tied to a leg of table or bed in a separate room every time I visited his family, made me always think that there has to be a better way to keep him safe. I was wondering what other ways can teach him, how to communicate effectively, and how we can provide a better life and future for him. Computer science, my bachelor and master's major, has opened my eyes to how much the technology can offer for humanity, and has led later to my research on how to get benefits from these technologies for people with disabilities.

The aim of the research is to develop a framework to find alternative affordable mainstream technology solutions for people with physical disabilities. The development of a framework that connects mainstream technology features and the abilities of people with physical disabilities will help technology specialists to provide more specific answers about the appropriate technologies that suit the abilities of people with physical disabilities. The number of trial-and-error process required will also be reduced. In addition, finding affordable mainstream technologies that fulfil the needs of people with physical disabilities will reduce the time spent waiting for assistive technology services to obtain funding for purchasing expensive assistive technologies. They may be able to afford the price of the mainstream technology or already they may own one without being aware of its features.

1.3 Research questions

In light of the motivations and aim of the research, the following questions have been formulated.

1. What are the factors that affect the selection of mainstream technologies for people with physical disabilities?

2. Can a framework aid the matching of people who have disabilities to effective mainstream technologies?

3. Can the mainstream technologies be effective alternatives to the traditional assistive technologies for people with physical disabilities?

1.4 Overview of the research process

In order to answer the research questions, the research process in Figure **1.1** has been followed. The process started to develop the conceptual framework by reviewing the literature. Then, the Mainstream Technology Selection Framework (MTSF) was developed including its four tools (Interview 1, the decision tool, the search tool and Interview 2). After that, the MTSF was refined in Phase 1 by applying the first three tools of the MTSF using two hypothetical cases. Next, in Phase 2 of refinement, MTSF was refined by applying the four tools of the MTSF using six participants. Last but not least, the MTSF was evaluated by specialists. Finally, the conceptual framework was refined based on the findings from Phase 1 and Phase 2. Further explanation of the research design and processes appears in Chapter 3.

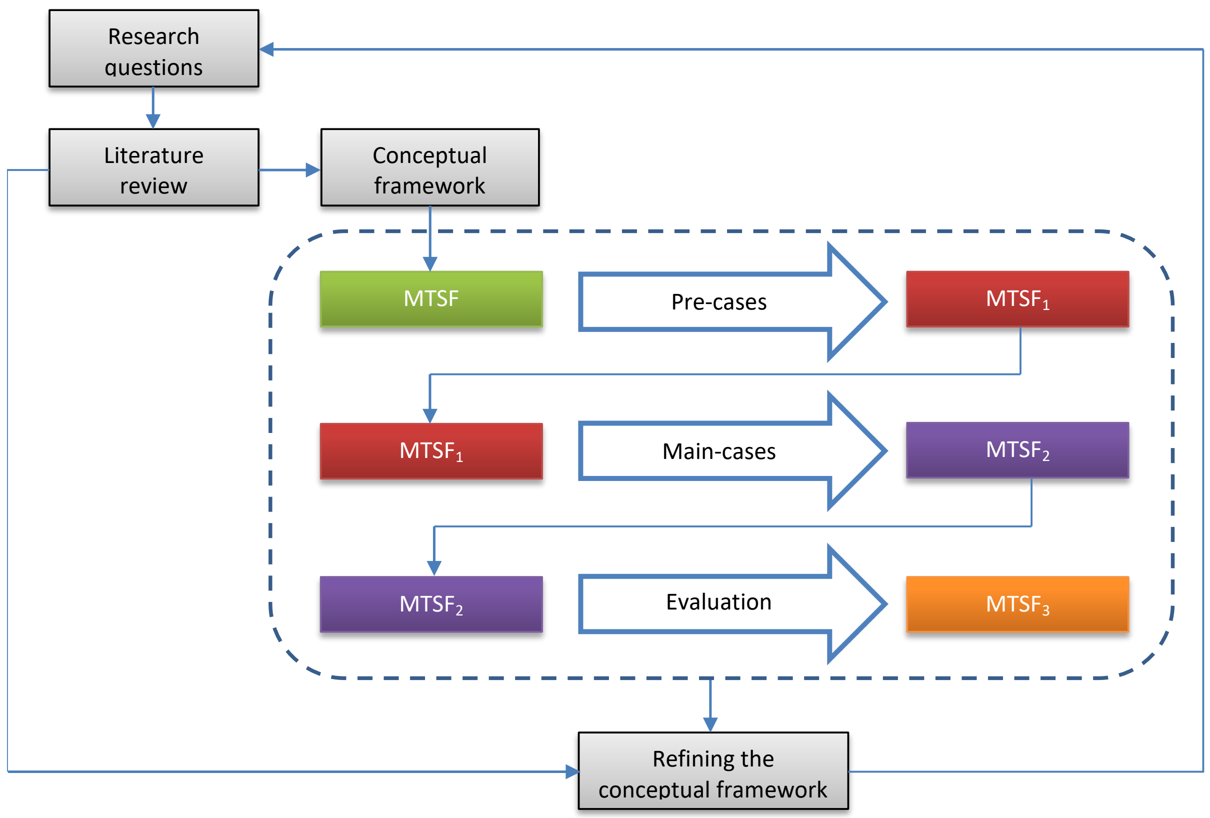

Figure 1.1. Overall research process

1.5 Setting the context

The aim of this section is to give a background overview of the research context: first, the disability definition and different models of viewing the disability; second, a definition of technology and the differences between assistive and mainstream technology; and finally, the importance of the technology for people with disabilities.

1.5.1 The disabilities

The WHO in 2001 published a first modified version of disability definition since the 1980s. The new part in this definition was the consideration of both medical and social perspectives. The modified definition is "Disability is an umbrella term for any impairment, activity limitation or participation restriction which limits functioning within contextual (personal and environmental) factors" (World Health Organization 2001, p. 213).

There are several classifications of types of disability. However, any type of disability could affect one or more of a person's functions, which include sensory functioning such as vision, hearing, and touch; physical performance such as muscle strength and movement; and cognitive skills such as attention span and problem solving (Heerkens et al. 2011). Moreover, even for people who have the same type of disability, they experience various levels of symptoms and conditions.

Disability restricts people’s functions in study, work, and many life activities depending on the type of disability (National Disability Coordination Officer Program 2009). My research will focus on the physical disability which will be discussed in detail in Chapter 2 including the physical and psychological symptoms. This research excludes hearing, vision, and cognitive disabilities, as the chosen technique for the data collection is the interview that required the ability to communicate with the researcher. The next subsection presents how we can look at the disability through two different models and how these models can affect the solutions that should be provided for people with disabilities.

1.5.1.1 *Medical Model versus Social Model*

We can look at disability from two different perspectives: the medical model and the social model. The medical model presents disability as a problem that prevents a person from participating in society or even being productive. The disability from the medical model perspective “is perceived to be caused by physical impairments resulting from disease, injury or health conditions” (Palmer and Harley 2012, p. 358). The medical model was widely used in rehabilitation practice because it considered a person with disability as a target that needed medical intervention. It was first introduced by the World Health Organization (WHO) in 1980 (Hersh and Johnson 2008) through its definition of the disability as “any loss or abnormality of psychological, physical or anatomical structure or function” (WHO 1980).

Conversely, the social model presents a disability as a natural condition and attempts to remove social barriers in order to facilitate the participation of people with disabilities in social activities. The social model concept was first introduced by Oliver (1983) as “a switch away from focusing on the physical limitations of particular individuals to the way the physical and social environments impose limitations upon certain groups or categories of people…adjustment within the social model, then, is a problem for society, not for disabled individuals”. It is an idea that challenges the medical model and its assumptions.

Consequently, the social model of disability is more suitable with assistive technology, because the main aim of assistive technology is to increase the opportunities for people with disabilities to participate in society and decrease the effect of environmental barriers (Hersh and Johnson 2008).

The next sections highlight the evolution of assistive technologies, the reasons for the high rate of abandonment of assistive technologies, and the situation of mainstream technologies in comparison with assistive technologies.

1.5.2 Technologies

Technology for people with disabilities is defined in the Standard Classification Assistive Products for Person with Disability (ISO 9999) as "any product, instrument, equipment or technical system used by a disabled person, especially produced or generally available, preventing, compensating, monitoring, relieving or neutralizing the impairment, disability, or handicap" (World Health Organization 2011a). As is obvious from the definition, the technology to assist the person with a disability is a wide umbrella that covers many kinds of products: low to high technology, hardware and software technology, and even non-technological products such as a head stick. It can also be specifically designed for people with disabilities or be more generally available. The specifically designed technology mostly considers the needs and abilities of the person with disabilities very carefully, which makes it the obvious and first choice. On the other hand, many technologies which are generally available have accessibility options allowing people with disabilities to use them. Although, considering the generally available technologies as an opportunity for people with disabilities is still debatable (Dobransky and Hargittai 2006), there is a consensus that these technologies can provide great benefits and advantages in education, work, and community participation by improving its accessibility and compatibility (Toboso 2011).

The next section presents the difference between specifically designed technology (assistive technology) for people with disabilities and generally available technology (mainstream technology).

1.5.3 Assistive technology versus mainstream technology

Caruso et al. (2013, p.638) defined assistive technology as "all kinds of accessible, adaptive and rehabilitative devices addressed to people with disability, aimed at improving their activities and participation and thus their quality of life. More recently, the term has significantly expanded its meaning to include, a wide variety of software solutions which replace, and in some case improve, the features originally provided by specific devices". The previous definition of assistive technology presents one of the most important differences between assistive technology and mainstream technology. The assistive technologies as mentioned in the definition are specifically designed for people with disabilities, which explains the high cost of assistive technology and leads to other difficulties such as availability (Borg and Östergren 2015; United Nations 2007)

Many studies mentioned the high cost of an assistive technology as one of the important factors for abandoning use of the assistive technology (further explanation in Section 2.7, Chapter 2). Thus, the trend in the world of the technology for people with disabilities focuses on affordable and available technologies such as using mainstream technologies.

Many examples of studies that used the mainstream technologies for people with disabilities showed promising results (Koester and Mankowski 2015), (Standen et al. 2011), and (Sesto et al. 2008). The results of these studies showed that in some cases the mainstream technologies can play the same role of the assistive technologies at a lower cost. For example; Standen et al. (2011) achieved acceptable results using the low cost mainstream Wii™ controller instead of an expensive custom joystick for controlling a computer. Furthermore, the mainstream technologies such as interactive apps on iOS systems provide low-cost or free alternative tools in many contexts such as education (Wiazowski 2014). Another supported example is using a mobile-based application instead of an expensive Braille device (Nahar et al. 2015).

The technology revolution offers many technology solutions such as hands free dictation such as Ok Google, Hey Siri, and Arabic support such as IOS 9's right-to-left.

The promising features that mainstream technologies can provide for people with disabilities and the ability to overcome many assistive technology problems make mainstream technologies appealing as alternative technology solutions for people with disabilities. Example problems of the assistive technology are the high cost, availability, accessibility, language barrier, and complexity of the design.

However, in the midst of the great diversity of mainstream technologies and their features, how we can select the most appropriate among the many solutions? The lack of a systematic way to guide the selection of the appropriate technology for people with disabilities even in an assistive technology context creates the gap. This research tries to fill this gap by providing a framework to assist the technology specialist in selecting the most appropriate mainstream technology solutions for people with physical disabilities.

The MTSF is specific to mainstream technologies because it pays intensive attention to the input/output features of these technologies. This is done by analysing the abilities of the person with disability to detect any need for specialization or extra technologies to maximize the efficiency and comfort for the user. In the case of assistive technology already developed for people with disabilities and even for specific types of disability, the input/ output features are tailored to accommodate the abilities of people from the targeted disability type. For example, Braille devices send input and receive output by depending on the touch sense. However, this does not mean that MTSF cannot be used for assistive technologies. It just fills a gap in the case of the mainstream technologies as their input/output features do not necessarily meet the needs and abilities of the person with disabilities.

1.6 Importance of technologies for people with disabilities

Technologies provide many opportunities for people with different types of disabilities to achieve better quality in different aspects of their life such as education, work, health, social life, and entertainment (Harris 2010).

The technology can improve some skills or even replace them in the case where the ability has been lost. Technologies such as communication devices can improve the communication ability of people with disabilities (Brodin and Lindstrand 2004; Krüger and Berberian 2015). In addition, using technologies such as environmental control systems can increase the independence of people with disabilities and reduce the need for caregivers (Craig et al. 2005). Furthermore, some technologies increase the ability to access information and the Internet (Davies et al. 2010). In terms of social involvement, technologies such as the Internet and social networks can improve the social engagement of people with disabilities (Raghavendra et al. 2013).

As a result, the technologies can improve many skills of people with disabilities such as independence, communication, access to information, and social involvement which leads to better education, facilitation of daily life activities, (Hoppestad 2007) and wider employment opportunities (Krüger and Berberian 2015).

1.7 Research contribution

This research is based on using activity theory as a theoretical framework. Applying activity theory in the context of disability is new and innovative. The activity theory includes the important high level concepts that play crucial roles in the interaction between the person and technology to achieve a goal. This research contributes to the activity theory by redefining the high level concepts to be applicable in the context of disability and exploring the relationships between these concepts.

This theoretical contribution is presented by developing a framework that:

- Groups and classifies the factors under each high level concept that affect the matching process between the person and the appropriate mainstream technology.
- Understands the relationships between these concepts.

From a practical perspective, this research contributes by developing a framework to assist technology specialists when they select an appropriate mainstream technology for people with physical disabilities.

In addition, the MTSF has been applied and tested in Saudi Arabia. Thus, this contributes to the research of technology for disability as there is a lack of research in this area: specifically in Saudi Arabia and generally in developing countries.

1.8 Scope of the research

Following are the dimensions that clarify the ambits of this research, help later in choosing the participants, and provide technology solutions for them.

Technology: the type of technologies that will be used in this research are mainstream technologies which are generally available and affordable and not specifically designed for people with disabilities. The focus was on electronic technologies, both hardware and software.

Disability: the focus of this research will be on the physical disability, excluding hearing, vision, and cognitive disabilities. The other types of disabilities were excluded because the research scope would be too large if all disabilities were covered. Furthermore, each type of disability needs to be specifically considered. As this research is qualitative research and uses semi-structured interviews to collect data from participants, it is difficult to do so without the ability of people with disabilities to communicate and respond to the questions of the interviews. In addition, the researcher thought it would be possible to provide mainstream technology solutions for people with physical disabilities.

The research focused on using electronic mainstream technologies without any adjustments in order to minimise the cost of solutions. However, if a person with disability cannot use electronic mainstream technology in its original form, then both hardware and software may need to be modified to help people with physical disabilities achieve their goals.

1.9 Thesis structure

This section presents an overview of each chapter. The thesis is organised into ten chapters: introduction, literature review, research design, conceptual framework, proposed Mainstream Technology Selection Framework (MTSF), refinement Phase 1 of the MTSF, refinement Phase 2 of the $MTSF_1$, evaluation of the $MTSF_2$, refined conceptual framework and conclusion.

Chapter 1: The introduction gives an overview of the research problem, research aim and motivation, research questions, and outline of the thesis chapters.

Chapter 2: The literature review presents an overview of the related works in the selection process of technologies for people with disabilities, as well as the identification and evaluation of major selection models and instruments used to recommend technologies for people with disabilities. Finally, there is a literature review of assistive technologies in developing countries, specifically in Saudi Arabia.

Chapter 3: The research design chapter presents a detailed description of the research design used in this study. It begins by stating the research objective and questions, followed by presenting a general view of the research processes. The starting point in the research design explains the philosophical assumptions that led to the choice of the research approaches, research methods, data collection and analysis techniques. This research used a qualitative approach with an interpretivist paradigm and a case study method. The data collection technique employed semi-structured interviews by using the instruments developed by the researcher. Then, the chapter describes the instruments used to gather the data and generate solutions. Next, it explains grounded theory as an analysis technique. The chapter concludes by discussing the limitations of the research method.

Chapter 4: The conceptual framework introduces the process used by the researcher to develop the conceptual framework. This process started by reviewing the literature about the factors affecting (positively or negatively) the use of the technology in general within the disability context. Then, the identified factors were classified and grouped to find out the core and high-level factors, which included the person, technology, environment, and goal. The next step involved reviewing the theories that could define these core factors and their interactions. Then, the activity theory was chosen as the theoretical framework for this research. The conceptual framework was developed by redefining the concepts of the activity theory based on the factors affecting the use of the technology.

Chapter 5: The proposed Mainstream Technology Selection Framework (MTSF) presents the developing of the MTSF by using the conceptual framework. It then explains the instruments of the MTSF including Interview 1, Decision tool, Dearch tool and Interview 2.

Chapter 6: Phase 1 of refinement presents the refinement of the MTSF. First, it introduces the purpose of conducting the hypothetical cases and the analysis technique. It then describes the method used including how the hypothetical cases were recruited, the description of the hypothetical cases, and how the first three tools of the MTSF were applied to reach the recommended technology solutions. Next, the findings from the interviews are presented. Finally, the implications of the applied MTSF along with how these led to the next phase of developing the MTSF are discussed.

Chapter 7: Phase 2 of refinement explains the refinement of the $MTSF_1$. First, it states the purpose of conducting the main cases and the analysis technique. Second, it discusses the method used, including how the participants in the main cases were recruited, the description of the main cases, and how the $MTSF_1$ was applied to arrive at the recommended technology solutions. Next, the findings from the interviews are presented under two main themes: 1) the technology and 2) the experiences of the participants before using the recommended technology and after having used the technology. The technology theme includes the advantages and disadvantages of the current and recommended technologies. The pre- and post-experience theme consists of the relationships emerging from the technology theme. Finally, the implications of the applied $MTSF_1$ and how these led to the next phase of developing the $MTSF_1$ are explained.

Chapter 8: Rehabilitation and occupational therapist evaluation of the MTSF is presented. The evaluation states the purpose of conducting the evaluation and also the analysis technique. It describes the method used, including how the therapists were recruited, their qualifications, and their relevant expertise. The evaluation is conducted on two levels: detailed evaluation and overall evaluation. Finally, the findings analysis of the detailed and overall evaluation are discussed.

Chapter 9: Refinement of the conceptual framework presents the redefined and new concepts and relationships, which emerged from the analysis and discussion in the refinement Phases 1 and 2. The chapter then discusses the impact of the new concepts and relationships on the proposed conceptual framework. Finally, the refined conceptual framework is presented.

Chapter 10: The conclusion summarises the work performed in the study, presents the theoretical and practical contributions of the research, and discusses possible future work.

Figure **1.2** presents the structure of the chapters of this research.

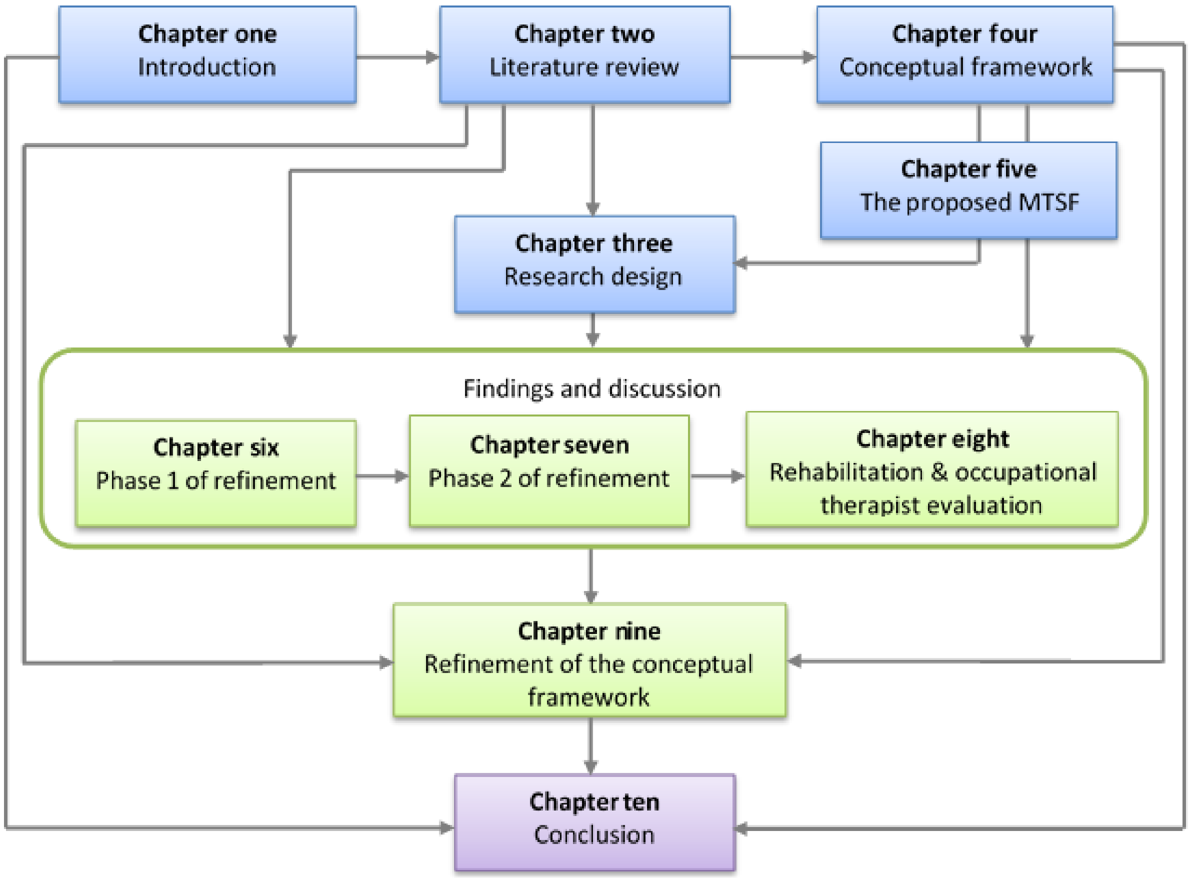

Figure 1.2. Structure of thesis chapters

1.10 Conclusion

This chapter gave an overview of the research problem, questions, and processes. Then, the context of the research was established including the adopted model of disability and technologies. Next, the importance of technologies for people with disabilities was introduced. Finally, the structure of the chapters of the research was presented. The next chapter presents a review of the literature on physical disabilities, the quality of life of people with disabilities, types of electronic technologies, the role that technologies play in the life of people with disabilities, and finally the existing frameworks for selecting assistive technologies.

Chapter 2

Literature Review

2.1 Introduction

This chapter presents an overview of the symptoms of physical disabilities, how the quality of life is affected when the person has a disability, the types of assistive technology currently available, the value of technology for a range of different people and circumstances, the use of mainstream technologies for people with disabilities and the abandonment of assistive technologies by people with disabilities. The chapter also presents related works in the selection process of assistive technologies for people with disabilities, as well as the identification and evaluation of major selection models and instruments used to recommend technologies for people with disabilities. Finally, the literature on assistive technologies in developing countries specifically in Saudi Arabia is reviewed.

2.2 Physical disabilities

A physical disability is a restriction or loss of body movement or control of movement. Physical disability can be caused by injury or disorder in the skeletal neuromuscular systems. Skeletal system injuries or disorders such as fracture, posture problems, and arthritis affected the body bones. Neuromuscular system disorders which affected nerves and muscles include but are not limited to: amyotrophic lateral sclerosis; multiple sclerosis; myasthenia gravis; spinal muscular atrophy; Parkinson’s disease and cerebral palsy (McDonald and Sadowsky 2002). The next sections present the most common physical and psychological symptoms of the physical disabilities.

2.2.1 Physical symptoms

Physical symptoms include the symptoms that are associated with a body part’s shape, movement, and/or the ability of movement control which affect the function of that part. The physical symptoms could affect one or more body systems such as the skeletal, muscular, and nervous systems. Consequently, the physical symptoms vary according to the affected body systems. The following subsections present the most important and common physical symptoms.

2.2.1.1 *Coordination problems*

The coordination problem can affect big movements such as walking, which for example can lead to falling down easily, or fine movements which are important while performing activities such as writing and driving. The coordination problem can be caused by either muscle weakness or nervous system disorders. As a result of fine movement difficulties, people with coordination problems need adaptive devices or technologies to be able to do these activities such as an adaptive keyboard for writing (Goldman and Schafer 2011; Subramony 2012).

2.2.1.2 *Muscle weakness*

People who have muscle weakness can't carry weight or complete most physical activities. The muscle weakness can result when the signals that should be sent to the muscle through the nerves are not strong enough. Also, muscle atrophy could be another reason for this condition (Preston et al. 2004; Warner and Sawyer 2012). Consequently, people with muscle weakness need assistive technologies that are light or can be mounted on assistive tools for them.

2.2.1.3 *Lack of muscle control*

Lack of muscle control occurs when the person cannot move the muscle to do an activity such as stretching out an arm to pick up something. There are three main reasons for lack of muscle control: problems in the muscles themselves such as weakness, problems in the skeleton because most of voluntary muscles are connected to the skeleton, or problems in nervous system (Chinnery 2011). Providing another way to access or control technology is essential for people with this problem.

2.2.1.4 *Loss of muscle function*

Loss of muscle functions or paralysis can affect different locations in the body. The spinal cord is the most common location. Person could lose muscle function because of brain injuries or nervous system disorders (Chinnery 2011; Griggs et al. 2011). People who are paralysed usually need positioning devices to help them in activities in daily life.

2.2.2 Psychological (emotional) symptoms

Psychological symptoms, which usually affect the people with physical disabilities, are a combination of emotions such as sense of shame (stigma), low self-esteem, and feelings of derogation and exclusion. There are different sources that cause or reinforce these feelings such as society or the person with the disability. The people with disabilities who look to themselves as different people who should behave and be treated differently are more likely to have negative feelings sometimes because of their disabilities and how they look or because they can't depend on themselves to do some activities. Furthermore, some of the special technologies that people with disabilities use to complete some activities, contribute to reinforcing negative feelings because people with disabilities consider these technologies a factor that attracts other people's attention to their disabilities. The second source of negative feelings can be the society's attitudes. Society's attitudes play a crucial role in strengthening or weakening the self-esteem of the people with disabilities. The acceptance of people with disabilities, manifested through encouraging them to contribute and participate in social activities and thus giving them the opportunity to express themselves are good examples of reinforcing positive feeling and vice versa (Parette & Scherer 2004; Wright 1983; Nguyen et al. 2007). The stigma is a normal result of other negative emotions such as low self-esteem and the feeling of derogation and exclusion. In addition, the stigma is directly related to being in public places. Thus, the public-stigma is the most common psychological symptoms of people with physical disabilities. The next section discusses this issue in detail.

2.2.2.1 *Stigma*

Stigma is a psychological condition when a person feels shame because of how s/he looks, behaves or moves. It is hard to change this feeling because it is necessary to increase the person's self-esteem and reduce the identification issue. The reason behind the stigma could be the person himself/herself or the environment around him/her (Wright 1983). Mostly, people with disabilities experienced stigmatized feelings as a result of social non-acceptance that affected their self-esteem and how they behaved. However, people with physical disabilities have a high rate of stigmatization because the physical disabilities are obvious. Understanding these feeling can explain different behaviours of people with disabilities. In the case of hidden disabilities, such as hearing difficulty, people with disabilities attempt to hide their disabilities by not communicating with others. On the other hand, people who have more visible disabilities such as physical disability choose to hide and not participate in activities (Wright 1983; Parette and Scherer 2004).

Alongside the role of social attitude in creating stigmatized feelings, there is the role of using assistive technology especially in later stages of life. Some people with disabilities refused to use an assistive technology such as a hearing aid or specially designed wheelchair because the assistive technology sends a message that they are vulnerable or need to be treated differently (Parette and Scherer 2004).

A device or technology used in their daily activities can direct attention to people with disabilities especially in public places such as school and work. People with disabilities mostly reject technologies that look different or do not enhance independence. Thus, introducing mainstream technologies (MT) as an alternative solution could reduce the rate of assistive technology abandonment.

The next section presents how quality of life is affected when the person has a physical disability.

2.3 The quality of life of people with physical disabilities

The quality of life of people with physical disabilities is measured by how well they cope with activities of daily living (Viemerö and Krause 1998). Due to their disabilities, people with physical disabilities usually face difficulties accomplishing some activities of daily living such as switching lighting on/off, making phone calls, opening/closing doors, changing the temperature of the room, controlling safety alarms, and keeping track of medical matters (Londral et al. 2015). Coping with the activities of daily living is not affected by how long the person has had the disability (Livneh and Antonak 1991). It is more related to how well the intervention and rehabilitation process assists the person (Viemerö and Krause 1998). The two most common types of assistance that people with physical disabilities receive are personal assistance and technological assistance. In 2010, the approximate cost of the personal assistance for people with physical disabilities in US was US$96 billion (Hwang et al. 2014). Hwang et al. (2014) also demonstrated that using technological assistance significantly reduces the need for personal assistance. The electronic technologies improve the feeling of independence by increasing their ability to control the environment (Anttila et al. 2012; Gentry et al. 2015), fulfilling the need of the person with a disability to feel secure

(Dobransky and Hargittai 2006). On a psychological level, this helps the person to cope and adjust to their physical disability (Rehabilitation Measures Database 2010).

The next section presents some of the electronic technologies which are used by people with physical disabilities to cope with activities of daily living.

2.4 The type of electronic technologies

Electronic technology is “any equipment or interconnected system or subsystem of equipment, that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information” (Federal Communications Commission 2014).

Given the difficulties that people with physical disabilities face due to their disability, the use of electronic technologies for people with physical disabilities would be a hard and frustrating task. For this reason, it is quite important to give them several options to make the accessibility of task easier (Belcastro 2005).

The following sections present the importance and limitations of the common types of electronic technologies in the disability context. Examples of these technologies are also presented.

2.4.1 Information and communication technology (ICT)

Information and communication technology (ICT) includes “any communication device or application, encompassing: radio, television, cellular phones, computers, and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning” (Rouse 2005). ICT has many benefits such as increasing economic development, enhancing social networks, and making services more efficient and easier. These benefits explain the rapid growth in using ICT around the world for several purposes. For example, 75 percent of the population around the world have access to cell phones, which is one of the common types of ICT. However, in developing countries, where the ICT infrastructure is poor, the access to cell phones and fixed broadband is too expensive for the majority (The World Bank 2016). In addition, most of the ICT are not specifically designed for people with disabilities (Seymour 2005) which increases the cost to make them accessible.

2.4.2 Accessibility technology

Accessibility in general is the ability of the person to access goods, products, and services. Successful accessibility considers many factors such as people's needs, abilities, material and human support, and the environment (Toboso 2011). Burgstahler (2001) grouped the accessibility barriers into three categories: providing input, interpreting output, and reading supporting documentations. He added that using assistive technologies could help people with disabilities to overcome these barriers and use technology such as computers independently. These assistive technologies that help in access are called accessibility technologies. If we take the people with physical disabilities as an example, they can access computers sometimes by using a standard keyboard. The standard keyboard provides features to overcome some difficulties. For example, the sticky keys feature overcomes the need to press more than one key simultaneously. Also for people who use one hand there are keyboards designed with special key arrangements for better access. For people with severe physical disabilities other options are available such as track balls, switches, and voice recognition systems. However, on the other hand, there are still some limitations with the available accessibility technologies. For example, despite limited accuracy, voice recognition systems are among the most common accessibility technologies for people with upper limb disabilities. Limitations include the need for training, accuracy of the software, and compatibility with other technology (Belcastro 2005). In addition, language is one of the limitations of voice recognition software. For example, Dragon is a common voice recognition software package with high accuracy. It is limited by its lack of support for some languages, such as Arabic. In this research, the accessibility technology is mainly used to improve the ability of the person with the disability to send and receive input and output. The accessibility technology is part of this research focus. The main focus is on the electronic mainstream technology itself and how we can use it - as it is - to enable people with physical disabilities to achieve their goals. However, if individuals are unable to access the mainstream technology due to their disabilities, the accessibility can be improved by different methods such as by using different mainstream hardware and software to support the main device (for example, using a track pad to access a tablet). More examples of accessibility technology that have been used with the participants in this research can be found in Sections 6.2 and 7.2.

2.4.3 Environmental control systems

Environmental control systems are systems that enable people to control objects around them remotely by using voice or switches in case of the people with physical disabilities. These systems enable people to perform tasks such as opening/closing a door, operating an entertainment device or alarm, or using a telephone. Beyond environmental control systems, smart home technology takes the controlling ability to a higher level. For example, smart home technology offers functions such as closing a roof window when it is raining. These functionalities can increase the independence of people with disabilities, by assisting them with their daily activities (Brandt et al. 2011). With all the benefits of the environmental control systems, they are still not popular or widely used among the people with disabilities nor financially supported or prescribed by specialists. Reasons for the unpopularity of the environmental control systems could be related to the people with disabilities themselves or the providers of these systems across aspects such as technical difficulties, lack of financial resources, inadequate information about the systems, and unrealistic user expectations (Verdonck et al. 2014).

Technology takes part in all aspects of life such as education, health, entertainment, and social life. According to the International Telecommunication Union (2014) the number of Internet users reached 3 billion users at the end of 2014, compared to the 2.7 billion at the end of 2013 - a strong indicator of the growth in the use of technologies in the past few years. Technology contributes in almost every area of our life from education and health to social life and entertainment. This contribution changes the way we interact with things and people around us. People with disabilities are not isolated from this change. On the contrary, technology for them is not just to make things easier or even more fun. They need help to be able to accomplish daily life tasks.

The next section presents a discussion on how mainstream technology can be made accessible for people with disabilities through changes or adaptations.

2.5 The use of mainstream technology in a disability context

Very few studies have been conducted to evaluate the ability of people with disabilities to use mainstream technologies. However, many of these studies show promising results. Few adaptions of the mainstream technology can make the difference for people with disabilities. Koester and Mankowski (2014) and Bani Hashem et al. (2014) demonstrated this idea. In both studies, they implemented software to adapt the setting of the computer mouse curser. Their software analyses the motion of people with upper limb disabilities such as involuntary tremors. Based on the collected data the setting of the mouse is adapted to meet the user's need. 70% of the participants in the Bani Hashem et al. (2014) study either agree or strongly agree that the mouse software improved their performance while interacting with the computer. In addition, the speed of the participants in the Koester and Mankowski (2014) study increased by 29%. In addition, Koester and Mankowski (2015) showed how the typing performance of people with physical disabilities in their upper limbs increased by automatically adjusting the keyboard features to accommodate the user needs. This result demonstrated that a computer could be accessed by people with disabilities, if features of the standard mouse and keyboard were adjusted.

However, finding a ready to use computer access device is an attractive idea. Standen et al. (2011) used a Wii™ controller to replace expensive custom made joysticks of people with intellectual and physical disabilities. Although the study did not show a significant difference between the performance of the participants who used Wii™ controllers and participants who used custom joysticks, the Wii™ controller still represents an alternative low-cost computer access device for people with intellectual and physical disabilities (Standen et al. 2011).

Burton et al. (2011) used Wii™ technology as well as thermal and visual tracking to capture the motions of the upper limbs of the patients after stroke. These motions are used as an input to a game that was specifically developed for training stroke patients on rehabilitation exercises to increase their upper limb motor skills. Burton et al. (2011) stated that the Wii™ technology and thermal and visual tracking provide a cheap alternative solution which can be installed at patients home to give them more flexibility on the time and period of training session. In addition, Wii™ technology could benefit people who live in remote areas by providing access to an affordable rehabilitation tool (Fung et al. 2012; Salem et al. 2012).

In the same context of rehabilitation therapy, Saposnik et al. (2010) compared using virtual reality Wii™ technology and recreational therapy to evaluate motor improvement after receiving standard rehabilitation. They found that compared to the group who used a recreational therapy, the group who used virtual reality Wii™ technology showed significant improvement in their motor skills after stroke. Furthermore, Wuang et al. (2011) used virtual reality Wii™ technology as an occupational therapy tool to improve the visual-integrative abilities and sensor-integrative functioning for children with Down's syndrome. Wuang et al.

(2011) compared the improving results of the children who used the Wii™ technology with another group of children who did not use it. The results show that children who used Wii™ technology outperformed the children who did not use it.

Moreover, Sesto et al. (2008) ran an experiment on sixteen participants, who suffered from moderate to severe cognitive disabilities, to evaluate their ability to use the mainstream cellular phone to make a call. The experiment was performed by using standard features in the phone: the flip and picture modes to avoid depending on memory because the user can use either a pre-programed single number or choose from four pictures on the screen. The result shows a 100% success rate in flip mode and 81% success rate in picture mode with just 30 seconds training. This high success rate demonstrates that the mainstream technology can be used by people with disabilities by using features that meet their needs. Similarly, Nguyen et al. (2007) conducted an experiment to examine the available off-the-shelf telecommunication options for people with physical disabilities. Nguyen et al. (2007) and his colleagues started by identifying the communication needs and accessibility problems for each participant, to match them with the appropriate telecommunication solutions. The researchers provided a trial session for the participants and conducted a performance assessment before, during, and after using the equipment. The result demonstrates the possibility of using off-the-shelf telecommunications equipment so that people with physical disabilities can make and receive calls and send and receive messages. In addition, the important result from this experiment shows that most of the ten participants had no knowledge about neither the available telecommunication options nor the features their current mobile phones could offer (Nguyen et al. 2007).

For people with disabilities, smart phones can be more than a device to make a call or send a message. Smart phone can be devices to save their lives as well. Vermeulen et al. (2015) creates a fall alarm system by implementing a fall detection application on different types of smart phones. The smart phones were attached to the participants' belts. The participants simulated ten different kinds of real falls. The results showed that the fall detection application on a smart phone can produce an effective fall alarm system for people with disabilities (Vermeulen et al. 2015). This fall alarm system can be developed more by making a smart phone send a message or call someone when the person with disability needs physical help.

Mainstream technology can also be used in supporter systems to add more features to the traditional assistive technology or make it easier to use as what Wiazowski (2014) did when he connected a Braille device to an app working on IOS devices such as iPad. The app used the Bluetooth feature to connect the teacher's computer to the Braille devices of blind students. The app called MBMimic works as a mediator to convert the Braille text to normal text and vice versa. The teacher can send the notes, instructions, and all other information to the blind students in his/her classroom; the blind students can share their works and ask questions. This combination of the traditional assistive technologies and the mainstream technologies provides a promising solution for blind students to continue learning Braille language for reading and writing while not missing the opportunity to be exposed to the new mainstream technologies for interacting with the people around them (Wiazowski 2014).

Accessing personal computers that are available in public places could be a challenge for people with disabilities. They are used to accessing their own personal computers using assistive technology tools such as magnifying tools or screen readers. Mulfari et al. (2014) suggested a cloud computing solution for this problem. People with visual disabilities can run these assistive technology tools (applications) on virtual machines by using virtual network computing. The virtual network allows them to access their personal computer environments that include the assistive technology tools from any network computer with a web-browser (Mulfari et al. 2014). The cloud computing technology could be the next revolution in the assistive technology industry.

Low-cost mainstream technology such as an ultrasonic sensor can be used to improve the performance of traditional assistive technology. That is what O'Brien et al. (2014) achieved when they attached a low-cost ultrasonic sensor to a traditional white cane which is used by people with visual disability. 10 out of 16 participants avoided more obstacles above the knee level by using the ultrasonic sensors attached to their traditional white canes. The traditional white cane cannot detect the obstacles that are above the knee level. The ultrasonic sensor helped to solve this problem and improve the overall performance (O'Brien et al. 2014).

As presented in the previous sections, the technologies play a crucial role in improving the quality of life of people with disabilities. However, the question that still has not been answered is why 5-15 % of people with disabilities do not have access to this important resource? Moreover, why the abandonment rate is still high among the people with disabilities who have access to assistive technologies. The next section presents some explanation of these issues.

2.6 The assistive technology abandonment

Even though the assistive technologies market is rapidly growing in recent years, there is still a high rate of assistive technologies abandonment from people with disabilities (Scherer and Craddock 2002; Evans and Johnston 2005). There are many reasons behind the high rate of assistive technologies abandonment. The problem starts even before purchasing the assistive technologies.

To guarantee at least using the assistive technologies with minimum difficulties, the proper assessment to match the person with the assistive technologies should be conducted before purchasing the assistive technologies (Beigel 2000) which also should involve the person with the disability so that his/her preferences and opinions can be considered (Betsy and Hongxin 1993). Involving the person in the selection of the assistive technologies also helps to measure the level of experience and reinforce the motivation to use the technology (Venkatesh et al. 2012).

Sometimes, assistive technologies do not keep pace with the modern world. This makes the users, especially young ones, less motivated to continue using them. Braille devices are an example (Wiazowski 2014).

The low effectiveness of the assistive technology is considered one of the reasons to abandonment it. For example when attaching a sensor to the cane of a person with visual disability to improve the feedback about the surrounding environment, the vibration generated from the sensor interferes with the person’s own feedback. The same happens when the auditory feedback is used because it interferes with the other environmental sounds.

The expense of the devices is a strong reason as well (Venkatesh et al. 2012), as most assistive technologies with high quality features sometimes cost up to thousands of dollars which is not affordable by many people with disabilities (Hersh and Johnson 2008; O’Brien et al. 2014). Some examples of expensive assistive technologies are Braille devices (Wiazowski 2014; Nahar et al. 2015), electronic travel aids (Ball 2008), and some commercial reach-assist devices (Khalid et al. 2014).

In addition, the complexity of the device reduces the probability of continuing use it (Hersh and Johnson 2008; O'Brien et al. 2014). The complexity includes the difficulty in wearing, using, and understanding the device as well as the difficulty in learning such as learning a Braille alphabet. The discomfort and pain are other reasons for abandoning the use of assistive technologies. For example discomfort can be experienced while using reach-assist devices (Khalid et al. 2014); or neck pain can occur while using a mouth stick (De Jonge and Rodger 2006).

Reasons that lead to non adoption or abandoning the use of assistive technology are more common in some countries more than others. For example; in countries where the resources are very limited and the people have very low income, the problems of technology availability (Nahar et al. 2015) and accessibility (Tripathi 2013; Nahar et al. 2015) are more common and widespread. Resources also include human factors such as people who are responsible of providing technology support and training for people with disabilities (Wiazowski 2014). In countries where the official and native languages are not English, mostly in developing countries such as Bangladesh, the language barrier is one of the important reasons for abandoning use the assistive technology (Nahar et al. 2015).

The next section gives an overview of the technology selection process including the criteria of the successful selection process.

2.7 Technology selection process

Assistive technology should be selected carefully to meet each individual's needs. Proper selection of assistive technology will increase the participation of people with disabilities in social activities. In addition, the selection of assistive technology is highly influenced by the type of activity in which a person wants to participate.

The assistive technology selection process is complex because there are many factors that need to be taken into account. Davies et al. (2010) found that nearly half of the study sample, which contains 60 people with cerebral palsy, were unaware of computer accessibility options that could help them access computers more effectively. They stated that the main reason of not being aware of the different assistive technologies and accessibility options available for people with cerebral palsy is the lack of knowledge either by clinicians or patients themselves. For clinicians they find choosing specific assistive technology for a child is difficult job due to the lack of effective research. In addition, the diversity of each person's requirements and the wide range of available commercial assistive technologies could make the prescription job even harder. Moreover, keeping up to date and completely knowledgeable is difficult because of dramatic changes and developments in the assistive technology field (Davies et al. 2010).

There is still a high rate of unused assistive technology, although the number of assistive technology options is increasing (Johnson 1999). Johnson (1999) reported that the reason behind the high rate of abandonment of assistive technology is that the selection process starts at the wrong point: technology is selected before the needs and goals of the user are detected. Friederich et al. (2010) asked practitioners about the theoretical framework used to select the appropriate assistive technology for their clients. One-third of the practitioners mentioned four models in regard to using a theoretical framework to select the assistive technology. However, only one model of the four was specifically for assistive technology. The rest were adapted from occupational therapy (Friederich et al. 2010). This result is a strong indicator of the lack of models that are specific to the assistive technology selection process. Moreover, Pousada et al. (2014) indicated that the need for developing a tool to assess the available technologies and their characteristics is an important issue because this tool can help to choose the technology with adequate properties for people with disabilities needs. In the same context, Hutinger (1996); Graham and Richardson (2012) emphasised the importance of having a proper assessment process for matching requirements to minimise the assistive technology abandonment's probability.

2.7.1 Criteria of successful technology selection process

To avoid the not-matching problem Hoppestad (2007) gave some advice about the assessment process to match the person with disability to the appropriate assistive technology. First, consider the assessment process as a dynamic process. This means that it has to be performed regularly to cover the all new changes in the person's life such as the change in health conditions for better or worse and the capability of physical movement, requirements or goals. Second, including observation and formal testing in the assessment process and allowing the person with disability to try the assistive device in a typical day gives a clear view of their daily needs. Moreover, consider the systematic assessment process as the starting point rather than the final decision. Finally, the assessment process should focus on the physical abilities, cognitive level, and environment factors which include anthropometrical, psychosocial, and physiological elements (Hoppestad 2007). Copley and

Ziviani (2005) emphasized the same points that had been mentioned by Hoppestad (2007). In addition, Copley and Ziviani (2005) added the importance of having instruments within the selection process so that the specialists can use them as guidance to collect the required information to conduct an appropriate technology selection. Moreover, they mentioned the importance of considering technology features and requirements related to availability, reliability, transportability, safety, comfort, ease of use, cost, and compatibility.

The next section describes in detail the three common existing models for the technology selection process. Each model description is followed by model evaluation from two perspectives: the literature perspective (if any) then the research perspective. Then, these models are compared against the criteria of the successful technology selection process. The comparison result is presented in Table **2.1**.

2.8 Existing models and instruments for the selection process

According to Polit and Beck (2004), a model is a set of concepts connected by relationships aiming to facilitate a complex procedure or represent a process or theory. For the assistive technology selection process, there have been many attempts to build a model, taking into account different factors that affect the selection process. The following are some of the common models which are frequently mentioned in the literature (Bernd et al. 2009; Friederich et al. 2010; Jenko et al. 2010).

There are many models and instruments that can be applied by practitioners to assess the status of a person, an environment, or the use of technology before selecting assistive technology. The most well known models specific to the assistive technology selection process are the Matching Person and Technology (MPT) model (Scherer 1991), the Human Activity Assistive Technology (HAAT) model (Cook and Polgar 2008), and the Lifespace Access Profile (LAP) model (Williams et al. 1995). Each one addresses the assistive technology component in a different way. However, the need to determine the characteristics of the technology and the robust method of matching the features with the abilities of people with disabilities is still missing (Pousada et al. 2014). The existing models gathered data but failed to translate that to a successful solution. Also, Blain et al. (2010) mentioned that even with the existing method of assistive technology selection there is still a lack of adoption which makes it hard to judge their effectiveness.

2.8.1 Matching Person and Technology (MPT)

The goal of the MPT model is to provide an easy process that facilitates matching a person with the appropriate assistive technology (Scherer 1991). The MPT model is considered one of the well known approaches in the assistive technology selection area that includes the user point of view (Urdiales 2012). While other assistive technology practitioners see the disability as something that has to be removed, the MPT model is the first attempt to consider the disability in getting benefit from the available resources while considering the person, technology, and environment to reach the optimal match between the disabled person and the assistive technology (Blackmon 2010). There have been some concerns over the model's value, for example Fok (2011) states that "although Scherer's approach has been heavily promoted, there has been limited published evidence that using the MPT makes a measurable difference in outcomes from device selection" (Fok 2011, p. 21).

The core components of the MPT model are the person who will use the technology, the technology, and the environment where the user will interact with the technology. The technology that will be chosen could be addressing a limitation in a person's ability such as a physical disability like blindness or just enhancing the person's performance to achieve a new goal (Scherer 1991).

Assistive technology selection instruments are tools used by practitioners to assess the status of the person, environment, and the use of technology before selecting the assistive technology. The instruments differ according to the assessment aim, for example, an instrument to assess the predisposition of assistive technology use. The assistive technology selection model could contain one or more instruments that support the systematic process of assessment. According to Friederich et al. (2010), there is a lack of assistive technology-specific instruments that include all the International Classification of Functioning (ICF) framework domains; body functions; restrictions in activity; and participation and environmental factors.

The MPT model contains five instruments. Each instrument has two versions: one for the user; the other for the professional, excepting health care technology assessment. The professional is responsible for advising the user of the best technology for his/her health situation (Scherer 1991).

2.8.1.1 *MPT model assessment instruments*

Survey of Technology Use (SOTU)

The SOTU instrument has two versions. The first version is for the user; the second is for the professional who tries to match the user with a general type of technology. Both versions aim to clarify the reasons that make the user comfortable or even uncomfortable when s/he deals with any type of technology (environment). The SOTU instrument for the user and professional is exactly the same form, however the same data is collected from both people to get different perspectives. The SOTU form focuses on the user experience in dealing with technology (technology), the activities the user frequently performs, and personal characteristics (Scherer 1991).

Assistive Technology Device Predisposition Assessment (ATD PA)

The overall aim of using the ATD PA is to indicate the incentives and disincentives which affect the future use of the recommended assistive technology device. It is used by the professionals who work in the rehabilitation field to measure the user predisposition to use the assistive technology device. In addition to the user and professional versions of this form there is an ATD PA scoring summary for the professional form and the ATD PA overall recommendations form. Both user and professional ATD PA forms cover the main three components of the MPT model: the characteristics of person, technology, and environment from two different perspectives. The ATD PA for the professional includes three sections:

a. Individual and psychosocial incentives and disincentives for assistive technology device use. For example: the person has expectations and mood toward using an assistive technology and a desire to get benefits from the assistive technology.

b. Requirements of the assistive device compared to the resources of the person. For example: physical and cognitive demands and cost of the device.

c. Individual and psychosocial characteristics affecting use of the assistive device. For example: the effect of using of the assistive technology on the view of others toward the person with the disability.

Noticeable on this form is the overlapping between the first and last sections.

The ATD PA for the user includes five sections:

a. The rate of the user's current capabilities in several areas such as vision and mobility. This capabilities assessment is very general. It will be described in the next section.

b. The rate of the user's satisfaction with what s/he has achieved in several areas. For example: communication skills and emotional well-being.

c. The feeling of the user toward his or her disability.

d. Personal characteristics. For example: independence and depression.

e. The feeling about using the recommended device (Scherer 1991).

Educational Technology Predisposition Assessment (ET PA)

The main goal of the technology in the education sector is to improve the quality of learning. The ET PA instrument gives the teacher a clear view about the learning experience which a particular group of students may need to enhance their skills. The two versions of ET PA cover the characteristics of the educational goal, educational technology, psychosocial environment, and the student (Scherer 1991).

Workplace Technology Predisposition Assessment (WT PA)

Again WT PA is designed to help the employers identify the factors that influence the use or non-use of the new technology in a workplace environment. Thus, the employers can set an appropriate training plan and decide which skills the employees need to improve before introducing a new technology. WT PA also covers the main components of the MPT model (Scherer 1991).

Health Care Technology Predisposition Assessment (HCT PA)

HCT PA is a specific instrument for professionals in the health sector to help them choose the appropriate medical device for the patient. The HCT PA instrument defines the functions and features of the health care technology, increasing the likelihood of appropriate use from the patient. There is one version of the HCT PA instrument covering the main components of the MPT model in addition to the characteristics of health problems and the potential consequences of health care technology usage (Scherer 1991).

2.8.1.2 *Initial steps for ideal use of the MPT model*

1. Fill the "Worksheet for the Matching Person and Technology (MPT) Model" form. This form identifies the initial goal and technology which will likely be useful for the user.

2. Fill the "Technology Utilization Worksheet for the Matching Person and Technology (MPT) Model" form which helps the professional to learn the technology that has been wanted, required, and used by the user.
3. Use the "collaborative model for matching person and technology" flowchart to help the professional make the assessment procedure more systematic by identifying the ideal instrument to be used.
4. Follow the procedures for the chosen assessment instrument.
5. Take advantage of the MPT model manual directions which relate to the chosen instrument (Scherer 1991; Scherer and Scherer 2006).

Although the evaluation of the technology selection models is rarely mentioned in the literature, the evaluation also just focuses on the view of scholars. It is extremely rare to find an evaluation which is developed based on a practical application of the model in a real context. The next paragraphs present evaluation opinions from the literature before concluding with the researcher opinion.

The MPT model focuses on the person. It takes into account the person's opinion, preference, and perspective to match the person with the optimal assistive technology. The cooperative work between the user and the professional will increase the result quality, the chance of using the assistive technology, and user satisfaction; reduce the abandonment rate of the recommended assistive technology (Wielandt et al. 2006). Similarly, Craddock (2006) reported that insufficient assessment of the person's needs and preferences and low involvement of the user in the selection process will raise the likelihood of the assistive technologies being abandoned (Craddock 2006).

Further, Scherer (1996), the author of the MPT model, reviewed the studies that outline the assistive technology abandonment reasons. She claimed that most of the reasons can be placed under one of the three main focus areas of the MPT model. The main focus areas of MPT model are person, environment, and technology. This is considered as a strong indicator that the MPT model covers the key and important elements for matching the person to the appropriate technology (Scherer 1996). Similarly, Wielandt et al. (2006) recommended using the MPT model as a guidance tool through the selection process for several reasons. The MPT model considers the person, environment, and assistive technology factors which influence the use of the assistive technology and usually have not been considered during the routine of assistive technology selection process. Moreover, the MPT model starts with identifying the goal of using the assistive technology for both the user and the professional (Wielandt et al. 2006). This strategy helps to build a solid and common base.

Many studies (Goodman et al. 2002; Scherer and Glueckauf 2005; Scherer and Craddock 2002) praised the effectiveness of the MPT model instruments, especially ATD PA, in identifying the factors affecting the use of the assistive technology as well as the reasons for rejecting use of the assistive technology after a short time. Moreover, the MPT model and its instruments have the ability to detect the areas where the user needs training, additional support, or any type of intervention to increase the optimal use of the assistive technology (Scherer and Craddock 2002).

In addition, Scherer and Scherer (2006) emphasize the positive results of the study of 30 professionals who used the computerized version of MPT model with at least one user. The majority of the professionals said that using the computerized MPT model leads to more satisfactory results for both users and professionals. They plan to continue using the MPT model in the future (Scherer and Scherer 2006).

Furthermore, the MPT model can be used after a period of using the recommended assistive technology to measure the changes in different aspects such as capabilities of the user, psychosocial factors, social participation, quality of life, and support (Scherer and Glueckauf 2005; Scherer and Craddock 2002). That can be done by comparing the completed instruments before and after using the assistive technology.

Scherer (1997) developed a model called Matching Assistive Technology and Child (MATCH), based on the MPT model, which targets children 5 years old and younger and contains assessment tools focused on the children and their families (Bernd et al. 2009). Heerkens et al. (2011) argued that the MATCH model does not assess the child while s/he uses the assistive technology, and as a result, the MATCH assessment cannot help determine whether the child needs further support in using the assistive technology properly.

On the other hand, Mumford (2011) reported that MPT model instruments are complex and very general tools (Mumford 2011). Price and Sears (2009) support this claim and explained that the questions in MPT model instruments are very general which means that the answers to these questions cannot give enough or specific details about the situation of each individual’s disability. Consequently, the professional cannot translate the answers to the exact function capabilities of the user (Price and Sears 2009). For instance, the ATD PA form includes a section for assessing the current disability situation of the user. However, the assessment contains nine points which have to be rated by the user on the scale from 1 to 5 where 1 indicates the lowest rate. The nine points are: vision, hearing, speech, upper extremity control, lower extremity control, mobility, dexterity, learning speed, and physical strength (stamina). The rating from 1 to 5 does not give the professional a clear view about the exact area of strength or weakness in the body, the type of that weakness, or the situation that enhances or reduces the weakness. Addressing this issue will improve the defining of the user situation and the quality of the intervention in reaching the optimal match.

The MPT model instrument: WT PA, HCT PA, ET PA, and ATD PA start by identifying the appropriate technology for the user. Then the rest of the forms assess the quality of that matching and try to detect any problem that prevents the user using the technology and the type of intervention needed. Consequently, the MPT model is not presenting the process that ends with a technology selection. Thus, the MPT model is a measurement of the quality of matching technology more than a selection process.

The MPT model is supposed to focus on three areas (Scherer 2012) as the model's author indicated. The three core areas are: the person's characteristics, the environment, and the technology characteristics or features. However, the technology features and requirements such as size, weight, access options, and output style are not presented directly in the instruments. The actual connection between the person's abilities and the technology features is absent. Presenting such information can assist the professional and users alike. The professional can focus the technology research in the intersection where the user abilities and the technology features meet; the user can select the technology that provides the most comfortable atmosphere of usage.

The MPT model aims to provide an easy process that facilitates matching a person with the appropriate assistive technology. The core components of the MPT model are the person who will use the assistive technology, the assistive technology itself, and the environment in which the user will interact with the assistive technology. The MPT model targets those aged 15 years and older (Scherer 1991). Scherer used the grounded theory approach to generate the model (Bernd et al. 2009). It is a user-based model, containing seven instruments for user assessments of abilities, preferences, and predispositions concerning assistive technology use in different environments (Jenko and Zupan 2010). The MPT model was adapted to identify the assistive technology and training needs of students with disabilities in educational environments. The positive attitude from students who used assistive technology selected under the MPT model emphasises the effectiveness of this model in practice (Scherer and Craddock 2001).

The assistive technology component is mentioned across the instruments of the MPT model. For example, in the Assistive Technology Device Predisposition Assessment (ATD PA) instrument, assistive technology is mentioned at a general level to compare three requirements of the assistive technology against the user's capabilities:

REQUIREMENTS OF THE AT		RESOURCES OF THE PERSON
23. Physical demands ________________________	☐	____________________________
24. Physical/sensory requirements______________	☐	____________________________
..		
..		
28. Cognitive demands________________________	☐	____________________________

Figure 2.1. Excerpt from the ATD PA instrument in the MPT model that mentions the assistive technology requirements against the user's capabilities

Using the tool depicted in Figure 2.1, the practitioner scores the quality of matching on a scale from 1 (clear mismatch) to 5 (good match). The score is general and does not give sufficient detail about exactly where mismatches occur and how to correct them. In addition, the MPT model focuses on measurement of the quality of the matching process more than the matching process itself. It is obvious that no part of the MPT model instrument addressed the technical features of the assistive technology and how the other components interact with them. Thus, this research focuses on addressing the technical features of the mainstream technologies to provide more specific technology solutions.

The next section presents and evaluates the second model of technology selection process.

2.8.2 Human Activity Assistive Technology (HAAT)

Cook and Hussey (2002) developed the Human Activities Assistive Technology (HAAT) model, which consists of the same three core components as the MPT model: humans, assistive technologies, and the environment (context), in addition to activity. The HAAT model aims to provide a framework for the selection, evaluation, and implementation of assistive technology. The base of the HAAT model is the human performance model (Bailey

1996), which is used in the human performance engineering field and contains the same components as the HAAT model. The human performance model does not include assistive technology.

Defining ‘activity’ is the starting point in the HAAT model since it was originally derived from an engineering background and is widely used in rehabilitation practice (Friederich et al. 2010). Unlike the MPT model, there are no assessment tools in the HAAT model nor have there been any validation studies (Jenko and Zupan 2010).

Compared to the MPT model, the Human Activity Assistive Technology (HAAT) model is less developed and evaluated for the assistive technology selection process, because the HAAT model and its components are not translated to forms which can be applicable in practice (Fok 2011). The application of the HAAT model takes several forms in the literature. The most common form is using the HAAT model to gather the needed information to design an assistive technology for a specific user. For example, Louie et al. (2009) used the HAAT model during what they called “prescription process” for gathering information about a woman with an upper limb disability. The information includes the user’s abilities, limitations, and social demographic. Louie et al. (2009) justified the use of the HAAT model to gather important information for designing a customized assistive technology, stating that the model provided a deep understanding of the user’s problem. When the professionals have a comprehensive view about the user’s problem, they can translate that to a better design which meets the user’s needs. The findings demonstrate the important impact of the sociocultural factors on the design of the assistive technology (Louie et al. 2009).

The social and cultural factors are clearly indicated in the HAAT model under the ‘context’ component. Cook and Polgar (2008) reported that the positive or negative sociocultural views toward using the assistive technologies or the disability itself, play a crucial role in using or rejecting the assistive technology especially in public places (Cook and Polgar 2008). In the same context, Dragoicea et al. (2009) reported that the HAAT model is appropriate for analysing, synthesising, and developing the assistive technology, more than matching the assistive technology to the person.

Moreover, many authors emphasized the appropriateness of HAAT model for the assistive technology design field for many reasons. The first reason is the strong attention of the HAAT model toward the user-technology interface design. Thus, the designer should focus on user needs and abilities to design an interface that is appropriate to the user (Hoffman 2009). The second reason is the ability of the HAAT model to cover the details of the surrounding context which includes: physical, social, and cultural contexts (Hoffman 2009). Also, the HAAT model differentiates between two concepts: skills and abilities of the person and connects the good understanding of these two concepts with the acceptance rate of the assistive technology by the user (Lenker and Paquet 2003). Finally, the HAAT model pays attention to the importance of the distribution of the tasks between the user and the assistive technology by using the function allocation concept which allocates the task either to the user or the assistive technology (Lenker and Paquet 2003). The function allocation depends on the skills and needs of the person, the ability to perform that function, and the cost (Hoffman 2009).

The HAAT model has been applied more in the human factors design field, even though Cook and Hussey (2002) supported using it as a guidance framework in selecting the appropriate assistive technology for a person's needs (Lenker and Paquet 2003) and also for design, evaluation, and examination of the effect of the assistive technology on participation in daily activities (Cook et al. 2010). The broad definition for the four components of the HAAT model allows different groupings of age, disability, assistive technology, and context to fit within this model (Lenker and Paquet 2003).

On the other hand, the specific definition of the relationships between the components and how these relationships affect the outcomes of the model is still necessary (Lenker and Paquet 2003; Brandt et al. 2004). Again, Haynes et al. (2009) reported that the HAAT model lacks applicable interventions to increase the human performance if the environment demands change, even though it addresses the impact of the environmental factors on the human performance.

Brandt et al. (2004) used the HAAT model to structure an interview which studies the impact of older people using powered wheelchairs. The interview contained the five sections: person, assistive technology, activity, environment comprising the HAAT model components, and outcome dimensions. He commented that the HAAT model presents the key factors which affect the outcome dimensions (Brandt et al. 2004). Naudé and Hughes (2005) stated that using models such as the HAAT model represents the impact of assistive technology on the user.

One of the advantages of the HAAT model is that the assistive technology selected by the model is kept as simple as possible. Cook et al. (2010) applied the HAAT model in a project which aimed to enhance the quality of life for people with disabilities by providing technologies for them. One case in that project was a 92 year old woman; her main need was to keep contact with her daughter. The main difficulty was that she could not use the standard phone. In this case, the team started by looking into the available technology such as computers and by adjusting the Skype communication program interface to be accessible by this woman and any person who has difficulties using the regular mouse or keyboard. The woman can now communicate with her daughter by audio and video (Cook et al. 2010). The solution in this case is kept as simple as possible by taking into account that the woman lives in a care facility. Thus, she needs technology to use in a limited environment. This property of the HAAT model comes from the dependence of the model on a hierarchy of assistive technology (Trefler and Hobson 1997) during the selecting of the assistive technology. Trefler and Hobson (1997) recommended keeping the assistive technology solution as simple as possible because that will reduce the chance of abandonment of the assistive technology. The steps of the hierarchy are shown in Figure **2.2**.

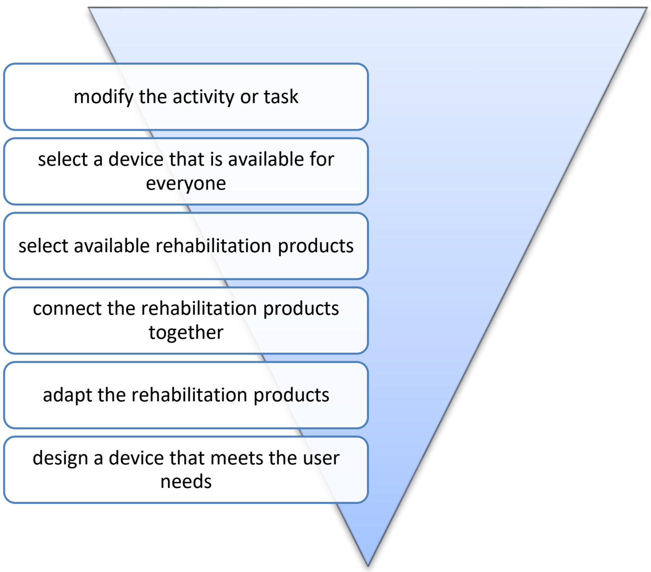

Figure 2.2. The hierarchy of assistive technology, modified from (Bailey 1996)

Another case in the (Cook et al. 2010) project shows how the reduced consideration of the factors under the main components of the HAAT model could affect the quality of the selection and design process. Sophie is a girl with Angelman Syndrome. The detection of her needs was done by her parent. After the team decided and designed the assistive technology which they expected was the best for her needs, Sophie refused to use the assistive technology. Simply the only mistake was that Sophie was not engaged in the need detecting process from the start. Thus, she lost motivation, which is a factor under the human component in the HAAT model (Cook et al. 2010). Consequently, considering the user's opinion during the selection process increases the user's motivation to use the assistive technology.

Another case in Cook's project raises the importance of support factors under the context component in the HAAT model. At the beginning, the user used the assistive technology perfectly, however after a while the assistive technology was returned. The team of the project noticed that the care giver of the user had been changed, which led to loss of the support she needed to use the assistive technology (Cook et al. 2010). An assistive technology that is working well under specific circumstances may not be the perfect match when some factors change.

In contrast to the MPT model, the technology component in the HAAT model has been given more attention through an explanation of the interaction between the technology and other components of the model.

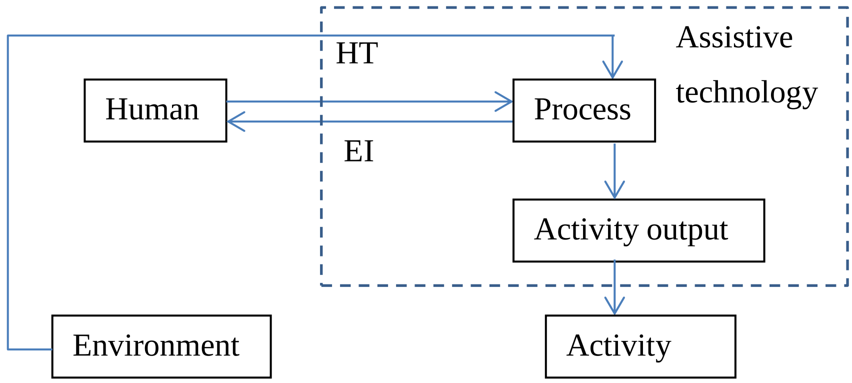

Figure 2.3. The interaction between the assistive technology and other components in the HAAT model

As shown in Figure 2.3, the assistive technology component in the HAAT model receives two inputs and produces two outputs. The first input is that from the person who uses the assistive technology through the human technology interface (HTI). The second input is from the surrounding environment, such as information about the road for blind people. The two outputs are the activity output and the environmental interface (EI). The activity output represents the task; the EI represents the output from the technology to the user.

Even though the assistive technology component in the HAAT model gives more details about how the assistive technology interacts with other components, it still lacks input and output features such as the format of assistive technology inputs and outputs and which format is more appropriate under specific circumstances. Thus, this research study focuses on connecting the abilities of people with physical disabilities with the appropriate input and output formats.

The next section presents the third technology selection model followed by its evaluation in the literature.

2.8.3 Lifespace Access Profile (LAP)

The Lifespace Access Profile (LAP) was developed by Williams et al. (1995). It is a person-based assessment in which a practitioner's team observes a person, to gather information about his/her abilities in five areas: physical resources, cognitive resources, emotional resources, support resources, and the environment in which the user intends to use the assistive technology. The physical resources involve information about senses, general health, muscle tone, coordination, mobility support, and the switch currently used. The cognitive resources contain information about the user's understanding of cause and effect of using the switch and recognizing the difference between picture, texture, and symbol switches. Also, it includes how the person reacts to the verbal and gesture directions? The emotional resources include rate of attention, distractibility, and predisposition to change. Support resources include moral support from surrounds such as family, caregivers, and professionals; logistic support such as adequate equipment, a training programme, and the time to implement that programme. Environmental resources such as home, school, and work. The profile indicates to what degree the person with a disability participates in these environments and how the assistive technology can help him/her to incorporate more. The Lifespace Access Profile is based on three principles:

1. The assistive technology chosen is affected by different factors. The needs and abilities of the person with a disability change over the time. As a result, the team of family members, care givers, and professionals from different disciplines cooperate to provide the best technology solution for the person.

2. The profile is a team-based instrument. The professionals from several disciplines work to evaluate the user from different point of view providing a comprehensive solution for each individual.
3. Keeping a balance between the technology need and available resources is important. The team cooperates to match the user with the best technology that can meet the user's needs. However, the resources sometimes are not adequate. This requires increasing the resources by promoting parent-professional relationships and providing more training for different situations.

The Lifespace Access Profile is not a structured test. It is a record where the team members from different disciplines are asked to rate a person's level of functioning and abilities on 59 scales from 1 to 10, where low scores indicate weaknesses and high scores indicate strengths. Then, the team uses the output of the LAP assessment to create an intervention plan and follow-up strategies, including any assistive technology that is needed (Williams et al. 1995). There is a version of the LAP assessment called the Lifespace Access Profile Upper Extension (LAPUE), which targets people who have physical disabilities but still have normal or higher cognitive abilities. Some changes are added to the cognitive scales to suit the high level abilities and needs of these people (Williams et al. 1995).

Heerkens et al. (2011) mentioned that LAP and LAPUE contain many promising features, such as including family in the assessment team members and the systematic approach of data collection. In addition, Copley and Ziviani (2005) support the same idea of LAP being a comprehensive assessment because it considers many of the effective assessment criteria which are mentioned in the literature. LAP takes into account views from different disciplinary team members. It considers also the factors that affect the implementation plan of the assistive technology. The factors are the human, equipment, support, and training resources. Again, identifying the priorities of the user's goals and determining the role of each member of the team encourage the best implementation and integration of the assistive technology in the user's life.

Furthermore, LAP assesses the user while using the assistive technology in a real situation to help assess components such as the access positioning, the distance from the assistive technology and the workspace angle (Copley and Ziviani 2005).

On the other hand, Copley and Ziviani (2005) reported a lack of researches that examine the effectiveness of LAP assessment in real life situations. Moreover, Layman et al. (2012) stated that even though the information gathered by LAP assessment is important to prescribe an assistive technology, it is not enough as a single assessment to prescribe a final assistive technology because the LAP assessment is not flexible enough to consider changes in the person's abilities or technology availability.

By applying LAP to a 7 year old student and reassessing him after 10 years, Layman et al. (2012) indicated the strong need of using an ongoing and flexible approach to implement the assistive technology which ensures tracking the user's goal and needs change over time. LAP also focuses on access requirements and has a lesser consideration of the different features used by different assistive technologies for other purposes.

Although LAP is considered a good systematic approach for data collection, it does not have a method to connect this data directly with the technical features of the assistive technology.

2.8.4 Comparison of the existing models

This research focuses on gaining benefits of the advantages of existing models to develop a specific framework for selecting appropriate mainstream technologies for people with physical disabilities. Some advantages of the existing models include systematic approaches to collecting required information, comprehensiveness of all persons' needs and abilities, and following-up to evaluate the effectiveness of the selected technologies. The need to develop a new framework (rather than tailor an existing framework) comes from the fact that the existing frameworks are 1) either not specifically developed to include mainstream technologies such as MPT; 2) adopted from another field (Human performance engineering) such as HAAT; or 3) developed for specific type of assistive technologies (Switches) such as LAP assessment.

The main contribution of the MTSF in this research is the use of the collected data concerning goals and the need to generate clear and explicit features of the candidate technology.

Next, Table **2.1** presents a comparison of the previous three common existing models (MPT, HAAT and LAP) against the key criteria previously discussed in Section 2.7.1.

Table 2.1. Comparison of the three common models for technology selection process against the key criteria of successful technology selection process

	MPT model	**HAAT model**	**LAP assessment**
References	(Scherer 1991; Jenko & Zupan 2010)	(Cook & Hussey 2002; Cook & Polgar 2008)	(Williams et al. 1995; Heerkens et al. 2011)
Instruments	Five instruments for several environments: SOTU, ATD PA, ET PA, WT PA, and HCT PA	No instruments	Record contains 59 assessment elements in five areas: physical, cognitive, emotional, support, and environmental resources.
Systematic process	Identify the appropriate technology based on the goal. Identify the technologies used, desired and needed. Select the appropriate MPT instruments. Use the manual for the instrument use instructions.	No systematic processes to follow. The practitioners use any method they want to collect information in light of the four main areas of the model: human, assistive technology, context, and activity.	Start by identifying the role of each practitioner's Assessment and Program Planning (goal, previous experience, reinforcements, and current status of the person) Indicate the available resources.
Clear identification of the goal	Worksheet for identifying the goal.	Desired activity component could represent the goal.	Identifying the goal by cooperating work between person, family, and practitioners.
Technology features and requirements	Not presented directly More development needed	Human-technology interface Processor Activity output Environmental interface	Doesn't mention the characterization of assistive technology.
Observations of the user in real situation	Collecting information by filling forms or interviews.	Collecting information via discussion or interview.	Assessing the user while using the assistive technology in real situations to help assess components such as the access positioning, the distance from the assistive technology, and the workspace angle.
Consideration of the changing user needs and abilities	Using the same instruments after a while of trying the assistive technology.	There is no further follow up after assistive technology prescription.	There is a strategy to intervene and follow-up, although it doesn't consider the changes in goals and needs over time.
Implementation plan	Action plan to address problems and describe proposed intervention.	No plan to follow up the use of the recommended assistive technology	It considers the factors that seem to affect the assistive technology implementation plan: humans, equipment,

	MPT model	HAAT model	LAP assessment
			support, and training resources
Reinforcements	Nothing related to reinforcements	Nothing related to reinforcements	Examples of things that cause negative or positive reactions from the person
Compatibility with ICF	Is not based on the ICF or any section of it.	Is not based on the ICF or any section of it.	Is not based on the ICF or any section of it.
Compatibility with ISO 9999	Is not based on ISO 9999 or any section of it.	Is not based on ISO 9999 or any section of it.	Is not based on ISO 9999 or any section of it.

The previous section has considered the comparison of the three well known models for technology selection against the criteria of the successful technology selection process. As the main part of the research was applied in Saudi Arabia, the next section presents the general situation of assistive technologies in developing countries, then the specific situation in Saudi Arabia including some barriers to implementing assistive technologies in these environments.

2.9 Assistive technologies in developing countries

The World Health Organization (2015) stated that 80% of people with disabilities live in developing countries (that is, low-income and middle-income countries) where only 5-15% of people who require assistive technologies have access to them. In addition, mostly, these assistive technologies are not efficient, because they are delivered by neither considering the importance of assessing the needs of the individual nor properly selecting the technology, training, and follow-up (Borg et al. 2011). The next section presents the situation of the assistive technologies in Saudi Arabia as representative of a developing country.

2.9.1 Assistive technologies in Saudi Arabia

Although Saudi Arabia is classified as a developing country, the telecommunication infrastructure meets the standard of a developed country (Saudi Arabian General Investment Authority 2016). However, disability services are lacking (Al-Jadid 2013). The Ministry of Health is responsible for the provision of medical services for people with disabilities. Normally secondary services such as physiotherapy and occupational therapy are provided by the general hospitals. People with disabilities in Saudi Arabia receive financial support from the Ministry of Labour and Social Development (Al-Jadid 2013).

Based on the definition of ‘disability’ by the World Health Organization, the number of people with disabilities in Saudi Arabia represents 3.73% of the total population, which is around one million people. However, studies about disabilities are limited, and most of them are about children with disabilities (Al-Jadid 2013). The limited research into disability in Saudi Arabia is partly due to social culture (Alfaraj & Kuyini 2014). Some families avoid participating in research because they feel ashamed of having a family member with disability. Some families tend to hide the family member with disability at home unless they have a hospital visit. Another reason for the limited research into disability in Saudi Arabia is the lack of institutions to provide current and accurate data about the disability situation (Alqurini 2010).

The Saudi government has items of legislation that consider the rights of people with disabilities to have equal levels of education, health care, rehabilitation, and social engagement (Al-Jadid 2013). Although the assistive technologies are a key factor in following this legislation, the implementation of the assistive technologies is still limited. To explore the reasons behind the limited implementation of assistive technologies in Saudi Arabia, the literature was reviewed regarding the barriers of implementing the assistive technologies in different contexts. However, most of this literature was in an education context.

Because of the dearth of published literature regarding this issue in Saudi Arabia, other Arabic countries were included in the reviewing process due to the cultural and resource similarities.

There are many barriers to implementing assistive technologies in Saudi Arabia. These barriers are related to economic, technical, and awareness issues.

The language barrier is an important factor that limits the implementation of the assistive technologies in the Arabic world. The marketplace lacks assistive technology to support the Arabic language (Al-Arifi et al. 2013; Al-Quwayfili & Al-Khalifa 2014; Alfaraj & Kuyini 2014). In addition, there is no common place to gather all effective and available Arabic applications for people with disabilities, such as a database. This makes it hard to find and ensure the effectiveness of the assistive technologies (Al-Khalifa & Al-Razgan 2014).

The second barrier that limits the implementation of assistive technologies in the Arabic world is the lack of assistive technology resources such as computers and well trained staff, especially in remote areas (Fakrudeen et al. 2013; Alfaraj & Kuyini 2014).

Moreover, people with disability lack awareness of the potential of assistive technology and its role in improving the quality of life of people with disabilities. This lack of the awareness extends to families and service providers. The awareness of the families includes understanding the nature of the disability and how to deal with it, understanding the importance of involving in the community, and understanding the medical intervention, but rarely do families additionally consider the role of assistive technology. In terms of the service providers the awareness excludes assistive technology as a core part of the service process. For example, the special education plan that is designed for students with disabilities does not consider the provision of assistive technologies as an important part of education accessibility (Alquraini 2010; Alquraini 2013).

2.10 Conclusion

This chapter started by giving an overview of disabilities including physical and psychological difficulties. Next, the common types of electronic technology were introduced. These types are information and communication technologies, accessibility technologies, and environmental control systems. For each type of the electronic technology, the advantages and limitations were discussed. Then, the literature highlighting the importance of the technologies in general in different sectors was reviewed. More specific literature addressed the importance of the technologies in improving the quality of life of people with disabilities. The next section presented some examples of using mainstream technologies for people with disabilities. Even though most studies showed promising results, the abandonment rate was still high. This was discussed in the assistive technology abandonment section to introduce the problem of the research. One of the most important reasons for the high rate of technology abandonment is the cost of the assistive technologies. This in turn led to the introduction of the mainstream technologies as an alternative solution. The next section presented the concept of the technology selection process and what makes it successful by discussing in detail the common existing models that have been commonly mentioned in the literature as tools for selecting an appropriate technology for people with disabilities. Finally, the chapter concluded by describing the situation of assistive technologies in developing countries and specifically in Saudi Arabia. The next chapter presents the research design of this study.

Chapter 3

Research Design

3.1 Introduction

This chapter presents a detailed description of the research design used in this study. It begins by stating the research objective and questions, followed by presenting a general view of the research process. The starting point in the research design explains the philosophical assumptions that led to the choice of the research approaches, research methods, and data collection and analysis techniques. This research used a qualitative approach with an interpretive paradigm and a case study method. The data collection technique employed semi-structured interviews by using the instruments developed by the researcher. Then, this chapter describes the instruments used to gather the data and generate solutions. Next, it explains the grounded theory as an analysis technique. This chapter concludes by discussing the limitations of the research method.

3.2 Research objective and questions

To obtain a clear understanding and justification of the research methodology, the research object and questions are reiterated.

The research objective is to find an alternative, affordable mainstream technology for people with physical disabilities by detecting the abilities of the person and matching them with the appropriate mainstream technology features.

To achieve the research objective, the following questions have been formulated.

1. What are the factors that affect the selection of mainstream technologies for people with physical disabilities?

2. Can a framework aid the matching of people who have disabilities to effective mainstream technologies?

3. Can the mainstream technologies be effective alternatives to the traditional assistive technologies for people with physical disabilities?

The following process was chosen to achieve the aim stated above:

- Literature review of the selection process of technologies for people with disabilities. The identification of major selection models and instruments that have been used to recommend technologies for people with disabilities. A review of the literature on the evaluation of the major selection models and instruments. Finally, a review of the literature on factors affecting the use or non-use of recommended technologies by people with disabilities and on social theory related to technology use. Development of a conceptual framework that represents the key elements should be considered when selecting technology for people with disabilities.
- Design of the mainstream technology selection framework (MTSF) based on the findings from the literature. The goal of the MTSF is to facilitate the process of mainstream technology selection for people with physical disabilities and to consider the factors that are likely to affect the use of the technology.
- Refinement of the proposed MTSF. Phase 1 involves two hypothetical cases. Next, Phase 2 includes six cases. In each phase multiple interviews to gather data about the abilities that people with disabilities have, the technology experience they have, how they have overcome disabilities in the past, what they wish to achieve and where the activity will be held, are conducted. Based on interview data, the technology will be introduced to the participants to use. Another interview will be conducted in Phase 2 to evaluate the selection. A refinement of the MTSF will be made after each phase.
- The final check was evaluation and confirmation of the MTSF by rehabilitation and occupational therapists.

Figure **3.1** represents the research process and its iteration.

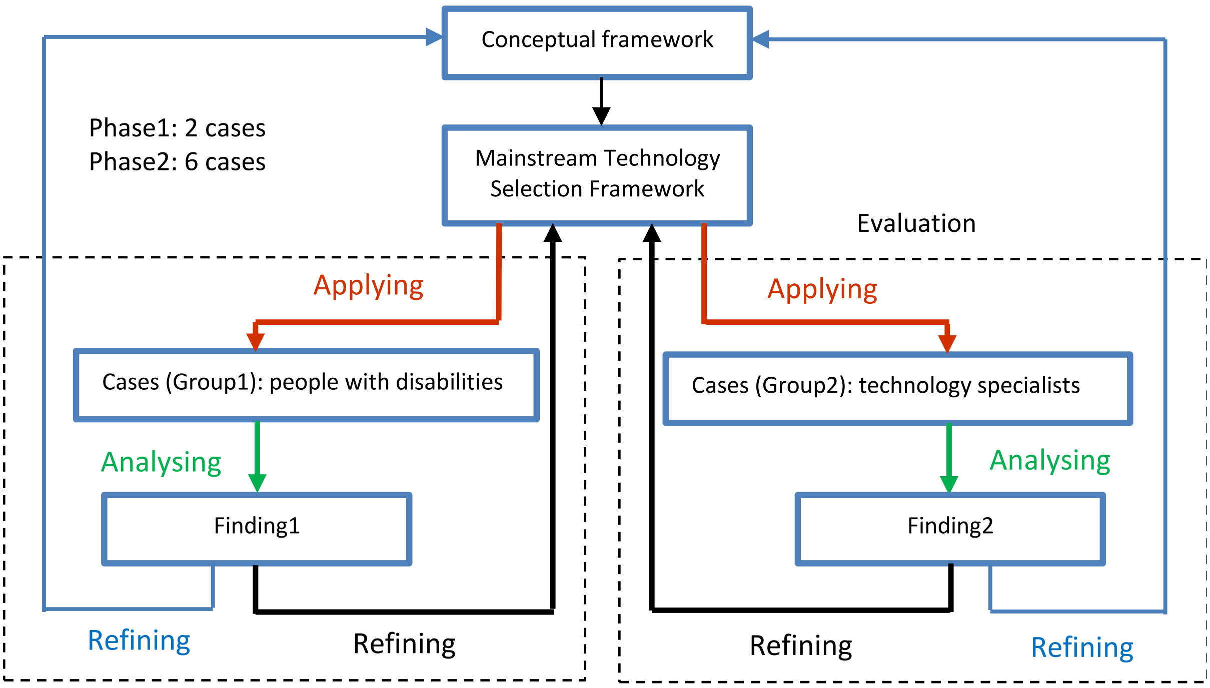

Figure 3.1. Structure of the research process.

3.3 Research Philosophy

In order to establish a solid research design, a position based on philosophical assumptions has to be determined. Thus, an appropriate choice of research paradigms will be justified based on viewing the philosophical assumptions from different perspectives. According to both Chua (1986) and Orlikowski and Baroudi (1991) the philosophical assumptions are divided into three main groups of beliefs:

Ontology: how a researcher views the world. The researcher can view the world as subjective where an empirical world depends on humans. Thus the world investigation has to be done through interaction with humans. Alternatively, the researcher can view the world as objective, where it is independent from humans and can thus be investigated without considering human interaction.

Epistemology: how the researcher constructs and evaluates the knowledge.

Methodology: how the researcher applies the knowledge in practice, leading to the determination of appropriate research methods and techniques that should be followed to obtain valid evidence.

The research paradigm is defined as "the basic of belief system or worldview that guides the investigator not only in choices of method but in ontologically and epistemologically fundamental ways" (Guba & Lincoln 1994, p.163).

Next, the research paradigms and the underlying philosophical assumptions of each one will be presented to justify the choice of the appropriate research paradigm for this research.

3.3.1 Positivist paradigm

The main principles of the positivist paradigm:

- The phenomenon of interest is single, tangible, and fragmentable. There is a unique, best description of any chosen aspect of the phenomenon.
- The researcher and the object of inquiry are independent. There is a sharp demarcation between observation reports and theory statements.
- There exist real, unidirectional cause-effect relationships that are capable of being identified and tested via hypothetic-deductive logic and analysis.
- The inquiry is value-free (Orlikowski & Baroudi 1991, p.9).

In regarding of the philosophical assumptions: ontology, epistemology, and methodology the position of the positivist paradigm is as follows.

Ontology: the positivist paradigm assumes the reality exists and is controlled by natural laws thus, the unidirectional relationships can be identified and tested independently of humans. Knowledge about objects in that reality is independent of time and context.

Epistemology: the relationship between the researcher and the objects in the phenomena is completely independent. The outcome of the research has to be uninfluenced by values and biases.

Methodology: the research questions or hypotheses should be empirically applicable and testable. If there are any ambiguity conditions, they should be carefully manipulated so the outcome is not affected (Orlikowski & Baroudi 1991; Guba & Lincoln 1994).

3.3.2 Interpretive paradigm

Interpretivists, as Creswell and Miller (2000, p.125) point out, "believe in pluralistic, interpretive, open-ended, and contextualized (e.g., sensitive to place and situation) perspectives toward reality".

Ontology: interpretivists assume that social reality is subjective. Thus we cannot understand the world independently without considering the researcher view and human interaction. The interpretive perspective assumes that the social world is produced by human action and interaction and can be only interpreted not measured. Also, the knowledge and interpretation can be transformed over time and context.

Epistemology: interpretivists assume that the researcher should interact with the objects in the phenomena under investigation. The distinction between ontology and epistemology can disappear because of a correlation between the researcher and the objects.

Methodology: from the interpretive perspective the appropriate methods to capture knowledge about the phenomena are embodied in field studies where the researchers should immerse themselves in the social phenomena to get information about people's thoughts, views, and experiences by using their own words (Orlikowski & Baroudi 1991; Guba and Lincoln 1994).

3.3.3 Positivist versus interpretive paradigms

Each paradigm has its own weaknesses and strengths although Orlikowski and Baroudi (1991, p.15) stated that "The researcher chooses between positivist and interpretive approaches based on the research question and the nature of the phenomenon of interest". The questions of this research take the form of how and what. Furthermore, the nature of the research problem considers the interaction between the technology and the person with disability, which leads to adoption of the interpretive paradigm. The philosophical assumptions of the interpretive paradigm are compatible with this research's view. The objectives are as follows:

Ontologically: the research takes a subjective perspective where it depends heavily on the participants' views and their understanding and interpretation of their environment and experiences.

Epistemologically: The researcher is specifically interested in understanding how the mainstream technologies can replace the assistive technologies, and what we need to know about the person, technology, and context to make this replacement successful.

Methodologically: the best way to apply the knowledge in practice is to use a research method and techniques that assist the researcher to gain rich and comprehensive data. This issue will be discussed in detail in the following section.

3.4 Research approach

There are two main approaches for research: qualitative and quantitative. The qualitative approach is research where the researcher tries to understand the phenomena from the participant's perspectives. It helps to gain an in-depth understanding about values, opinions, and a social context about a specific group (Trauth 2009). On the other hand, the quantitative approach "can be constructed as a research strategy that emphasizes quantification in the collection and analysis of data" (Bryman 2012, p.35). The choice between these two approaches depends on the research questions and the type of the phenomena under investigation. In order to justify the choice of the approach for this research the characteristics of the qualitative approach are presented in Table **3.1**.

Table 3.1. Characteristics of qualitative research approach (adapted from Trauth (2009, p.3), Johnson (2014, p.34) and Merriam (2014, p.18)).

	Qualitative approach
General framework	Seeks to explore phenomena
	Uses flexible, iterative instruments to elicit and categorize responses to questions
	Uses semi-structured methods such as in-depth interviews, focus groups, and participant observation
Analytical objectives	To describe variation
	To describe and explain relationships
	To describe individual experiences
	To describe group norms
	To understand the phenomena
	To capture meanings
	To generate hypothesis
Question format	Open-ended

	Qualitative approach
Data format	Textual (Obtained from audiotapes, videotapes, field notes, interviews, observations, or documents) The researcher is the primary data-collection instrument.
Study design	Flexible, evolving, and emergent Participant responses affect how and which questions researchers ask next. (For example, there can be addition, exclusion, or rewording of particular interview questions.)
	Iterative Data collection and research questions are adjusted according to what is learned.
Sample	Small, non-random, purposeful, and theoretical
Focus	Wide-angled and "deep-angled", examining the breadth and depth of phenomena to learn more about them.
Findings	Comprehensive, holistic, expansive, and richly descriptive.

This research employed a qualitative approach, which is based on interpretivism. This approach assumes that the human experience gives meaning to the social reality. Therefore, to achieve an interpretive understanding, interpretive researchers should understand the social reality from the people's perspectives (Hevner et al. 2004). Consequently, the qualitative approach gives researchers a good source of description and explanation of the identifiable problem in its context (Trauth 2009). In addition, the qualitative approach helps in producing a conceptual framework, as it provides further information about the initial conceptions (Miles & Huberman 1994). Bazeley (2007) supported Miles and Huberman (1994) argument that a qualitative approach is chosen when the researcher needs to reach a deep understanding of a process or experience of phenomena under investigation.

Miles and Huberman (1994, p.10) pointed out that "qualitative data, with their emphasis on people's lived experiences, are fundamentally well suited for locating the meaning people place on the events, processes, and structures of their lives". The answer to the research questions requires a deep understanding of the current situation of people with disabilities. The current situation includes their experience in using technology and what they expect or want to achieve by using a new technology. Then the qualitative approach is considered an appropriate choice to gain the required data.

Moreover, Trauth (2009, p.1) mentioned that "qualitative methods are also effective in identifying intangible factors, such as social norms, socioeconomic status, gender roles, ethnicity, and religion, whose role in the research issue may not be readily apparent". For this research, a fundamental step involves understanding the technology being used or intended for use, factors related to the individuals themselves, and environmental factors. This step would not be achievable using a quantitative approach.

Although the qualitative approach emphasises gaining a deep and complex understanding of the study's sample and the phenomenon, findings from qualitative approaches can be still generalized on the same populations who have the same characteristics as the study's sample (Trauth 2009).

3.5 Research method

According to Creswell et al. (2007) there are five methods to conduct a qualitative research: narrative research, case study, grounded theory, phenomenology, and participatory action research. However, in order to choose the appropriate research method, Yin (2009) offered three criteria which can help the researcher to answer the research questions by choosing the appropriate research method to conduct the task:

- The types of the research questions

Yin (2009) classified the type of questions which group the choice of the research method into two categories:

- "What" questions, which can be exploratory. Any research method can be chosen to conduct the research, although surveys or analysis of archival record methods are preferred to conduct the research.
- "How" and "why" questions, where the case study, experiments, or historical methods can be chosen.

As we can see, there is an overlap between the research methods if we just want to depend on the question type to choose the appropriate research method. The main question type in this research is the "how" question, which means either case study, experimental, or historical methods can be used to answer this type of question. How can we choose between them? This leads to the second and third criterion. The two other criteria to clarify the method choice as suggested by Yin (2009) are:

- The extent of access and control a researcher has over the actual behavioural events
- The degree of focus on contemporary as opposed to historical events

In terms of the two criteria immediately above, it is obvious that historical study is heavily dealing with the past, has no control over the actual behavioural events, and also has no access to participants or people who were involved in that event. On the other hand, experimental methods conducted in the laboratory where the researcher has control over the actual behavioural events enable him/her to control one or two dependent variables. Finally, when the event under investigation is a contemporary event and there is no control over the relevant behaviour, the case study is considered as the appropriate choice.

3.5.1 The adopted method

Yin (2009, p.18) defined the case study as a research method in two parts. The first part considers the scope of the case study:

"1. A case study is an empirical inquiry that

- investigates a contemporary phenomenon in depth and within its real-life context, especially when
- the boundaries between phenomenon and context is not clearly evident."

The second part considers the data collection and analysis strategies:

"2. The case study inquiry

- copes with the technical distinctive situation in which there be many more variables of interest than the data points, and as one result
- relies on multiple sources of evidence, with data needing to converge in triangulating fashion, and another result
- benefits from the prior development of theoretical propositions to guide data collection and analysis."

Although the historical and case study methods overlap especially when the historical study deals with contemporary events, the case study method is still unique in terms of its ability of having direct observation of the events and interviews of people who involved in the event (Yin 2009).

The questions of this research take the "how" and "what' forms which according to (Yin 2009) can be answered using survey or case study methods after excluding the experimental and historical methods for the reasons above. However, based on the definition of the case study and the criteria of choosing the appropriate research method, this research adopted the case study method over the survey method for the following reasons:

- The research deals with contemporary events.
- The researcher has no control on the actual behavioural events.
- The phenomenon under investigation needs rich and comprehensive data to be understood, which the survey method cannot provide. However, the case study method is an opportunity to explain comprehensively the components of the social situation by using a qualitative approach (Babbie 1995).
- It helps the researcher to understand a single case and then compares the similarities and differences across cases, which increases confidence in the results (Miles & Huberman 1994).

3.5.2 Case study design for this research

The first and most important point in a case study design is determining the type of the case(s) that the researcher intends to use. There are two type of case: single-case and multiple-case study design (Yin 2014). This research adopted a series of single-cases for two reasons:

- This research used the activity theory as a theoretical foundation (as discussed in Chapter 4) to develop the mainstream technology selection framework which is new to the disabilities context. Thus, as Yin (2014, p.51) stated "the single-case can represent a significant contribution to knowledge and theory building by confirming, challenging, or extending the theory".
- Each case has been studied at two different points: the first before using the mainstream technology; the second after using the mainstream technology. This meets another single-case rationale which is the longitudinal case where the same single-case has to be studied at two or more different times (Yin 2014).

The case study design consists of: determining the unit of analysis, case study protocol, and selection of cases. The following sections outline these three points in detail.

3.5.2.1 *Unit of analysis*

The unit of analysis (case) can be defined based on the natures of the research problem, research questions, and boundary of the cases. The natures of the research problem and research questions help to determine the data to be collected. The boundary of the cases identifies the individuals who should be excluded from the research scope (Yin 2014). The unit of analysis for this research is a person with physical disability.

Due to the difficulty of finding participants, the planned total number of cases in this research was ten cases, divided as follows:

- Two cases (as hypothetical cases) to test the MTSF. These two cases were recruited through a disability organization in Australia.
- Six cases (as main cases) to refine the MTSF (refer to Figure **3.1** for the iterative process). The six main cases were recruited through a disability organization in Saudi Arabia. The actual tools were translated from English to Arabic language by a professional translator. After conducting the interviews in Arabic the researcher translated them back to English. However, to guarantee the accuracy of the translation, random parts from the Arabic interviews were translated from Arabic to English by a professional translator; the two translations matched by approximately 95%. The duration of the interviews ranged from 31 minutes to 1 hour and 19 minutes. The interviews were conducted from January to April 2014. The interview location varied from case to case (see Section 7.2.1 for more details).
- Two cases involved two specialists: a rehabilitation therapist and an occupational therapist. The specialists were recruited through governmental hospitals in Saudi Arabia.

3.5.2.2 *Protocol of case studies*

Miles and Huberman (1994, p.27) stated that "qualitative samples tend to be purposive, rather than random". As a result, setting the criteria that the researcher will rely on to select the research cases is a crucial step. One typology of sampling strategies in qualitative inquiry is a criterion referred to by Miles and Huberman (1994, p. 28) as including "all cases that meet some criterion; useful for quality assurance". The person with physical disability was selected based on the following criteria:

- The age should be above 18 years to ensure their exposure to technologies and experience in dealing with it.
- In terms of the type and extent of disability, persons who have an upper body physical disability (without cognitive, hearing, or vision impairment) are included. The exclusion of multiple disabilities was done to facilitate the interview process.

- The persons should be able to communicate verbally, as the data collection technique is semi-structured interviews, which require explanation and further discussion with the researcher.
- The person has the desire to try new technologies and give his/her opinion about it.

The first phase comprised two hypothetical cases (pre-cases). These pre-cases resulted from a disability worker completing Interview 1 with hypothetical responses based on her experiences of working with people with disabilities. Then the researcher used the decision tool and search tool to allocate the appropriate technology solution for each case. The purpose of the pre-cases was to make sure that the right questions were asked in the first interview and important information was collected to make an appropriate technology selection.

In the next six cases, the cases for the main study were selected through an organization for people with motor disabilities (Harakiah) in Saudi Arabia. There are advantages to conducting the main study in Saudi Arabia. First, the researcher is a native speaker of the Arabic language which enhances the richness and the meaning of the data. Being a native speaker enables the researcher to fully understand hints, shortcuts, and local sayings. During this stage, the researcher applied the whole four steps of the developed MTSF to all six cases. The starting point is interviewing the person to assess his/her needs and abilities (Interview 1). Then, the researcher processed the collected data using the decision and search tools. The researcher met the person again to introduce the recommended technology. After using the technology for a period of time, the researcher conducted the second interview (Interview 2) to evaluate the effectiveness of the technology. The purpose of this stage is to refine the MTSF. (Details of cases, recommended technologies and the duration of use are discussed in Chapter 7).

3.5.3 Research instruments

The instruments of this research are the four tools of the MTSF (see Chapter 4 and 5 for the development process). The four tools including Interview 1, a decision tool, a search tool, and Interview 2. Figure **3.2** presents the workflow of applying the MTSF tools to find mainstream technology solutions for participants. Next, a brief description of each tool (see Chapter 5 for the detailed description).

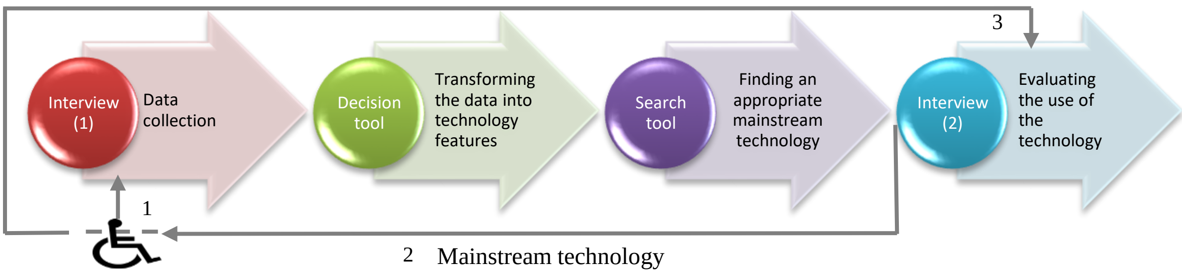

Figure 3.2. Mainstream technology selection framework workflow

3.5.3.1 *Assessment of needs and abilities (Interview 1)*

Interview 1 is a semi-structured interview that aims to collect data about three main themes for use in the next tool (decision tool). Interview 1 questions are presented by the practitioner to the person with the disability. The three themes: task, person, and environment are derived from the conceptual framework.

3.5.3.2 *Decision tool*

The decision tool represents the second stage of the mainstream technology selection framework. The aim of this stage is to map the data collected by Interview 1 into technology features. The decision tool is represented by using a decision tree model. The first level is the task, which is the first theme in Interview 1. The task detects the main function of the technology. The second level includes the person and the environment, which are the second and third themes in Interview 1.

3.5.3.3 *Search tool*

The search tool is the third stage in the technology selection framework. A flowchart diagram has been used to represent the process of searching for a mainstream technology using the information generated from the decision tool. The aim of the search tool is to find mainstream technology through research (e.g. via technology magazines, technology databases, or the internet) that meets the person’s needs based on the data collected from Interview 1 and processed by the decision tool.

3.5.3.4 *Evaluation of technology effectiveness (Interview 2)*

Interview 2 follows the same structure as Interview 1. Interview 2 is a semi-structured interview that aims to evaluate the effectiveness of the recommended mainstream technology. It includes three themes: the goal, the technology, and the environment. Interview 2 is used after the person tries the technology for a period of time so s/he has the required knowledge and experience about how to improve his/her performance using the technology.

After giving a brief description of the four tools of the MTSF, Table 3.2 shows how the four tools fit together and how the data transits from tool to another.

Table 3.2 Transition of data between the four tools of the MTSF.

Interview 1	**Decision tool**	**Search tool**	**Interview 2**
Collect data about needs and abilities	Process the data from interview 1 to generate technology features	Allocate the recommended technology based on the generated features from the decision tool	Evaluate the effectiveness of the recommended technology in regards the following points:
Identify the main task	Identify the main function of the technology	Search for the main function of the technology	Goal achievement
Experience of using technology	Experience: Overcoming previous disadvantages Benefitting from previous advantages	Technology has to meet the specialization requirements and overcome the previous difficulties	Ease of use Comfort Physical and emotional difficulties Physical and technical features
Person abilities detect input and output options	Interaction methods Input Output	Technology has to meet the input and output methods	
Environmental factors Physical environment Other people	Physical features (size, weight, external design, and visibility) Technical features (battery and screen) Additional supportive technologies	Technology has to meet the environmental requirements	Accommodating the environmental factors

3.6 Research techniques

3.6.1 Data collection

Many sources of data are used in case study research. However, the main common sources are documentation, archival records, interviews, direct observations, participant-observation, and physical artefacts (Baxter & Jack 2008; Yin 2012; Yin 2014). This research used interviews as the main source of data. The following section justifies this choice.

3.6.1.1 *Interviews*

The interview technique is considered a lens to directly access the individuals' experiences regarding the issue (Silverman 2013). The interview type which was adopted in this research is a semi-structured open-ended questions interview. In this type of interview "the researcher has a specific topic to learn about, prepares a limited number of questions in advance, and plans to ask follow-up questions" (Rubin & Rubin 2012, p.31) thus the questions are used as guidelines of conversation while focusing more on the planned concepts (Bryman 2012; Silverman 2013). The main two objectives of data collection process are:

- Testing the quality of the performance of the developed framework.
- Getting more and comprehensive understanding of the factors that affecting use/non-use of mainstream technologies.

To achieve that level of data richness, the semi-structured open-ended questions interview was selected because this type of interview transfers the interview from question-answer mode to conversational mode (Yin 2012). This assists the researcher to lead the interview to the most important points, get more information about things by asking for clarification, and pay attention to new concepts that are just mentioned by the interviewees.

The researcher intended to understand the factors affecting use/non-use of mainstream technologies from the perspective of the interviewees. The flexibility of the semi-structured interview offers this insight by following the interviewee's conversation direction (Bryman 2012) and understanding things through the lens of the participant (Silverman 2013).

It is worth mentioning that the researcher had difficulty gaining access to people with disability via the support organisations in Australia such as Cerebral Palsy Support Network (CPSN), Muscular Dystrophy Association (MDA), Motor Neurone Disease (MND) and Leadership Plus. The expected reasons for that were that the people with physical disabilities in Australia received advanced services through private and governmental centres. Moreover, the technology evolution has been accepted and applied in the daily life of people included people with physical disabilities.

After developing Interview 1 and Interview 2 questions (refer to Chapter 5 for the development process), ethics approval was obtained from the Monash University Ethics Committee. Potential participants were contacted through physical disability organizations. Their agreement to participate was solicited through discussion. Then, the explanatory statement was sent to those that agreed, so they would have a clear idea about the research and the tasks in which they would participate. The consent form was signed by the participants on the day of the interview, which included their agreement that the interview would be digitally recorded, which enabled transcription of the interviews and deep delving into the meanings and experiences that the participants provided through the interviews rather than the researcher having to focus on writing. The participant's responses were in the Arabic language as the interviews were conducted in Saudi Arabia. The interviews were translated and transcribed by the researcher.

3.6.2 Data analysis

Starting analysis of the data in early stage of data collection process gave the researcher the opportunity to become familiar with the data and to determine how to direct the next round of data collection, such as clarifying ambiguous questions, asking for more details and changing the way of asking some questions. This research had two sources of data collection: interviews with people with physical disabilities and questionnaire and interviews with specialists. Each source collected different data from different perspectives. Consequently, the collected data from people with physical disabilities was analysed separately from the collected data from specialists. However, the output of analysing the two sources led to the same purpose which was refining the MTSF. The data analysis strategy and technique used in this research will be presented in the following sections.

3.6.2.1 *Analytic strategy*

As will be presented in detail later in the limitation (Section 3.8), the case study method has no systematic procedures for data analysis. According to Yin (2014, p.142) "the best preparation for conducting case study analysis is to have a general analytic strategy. The purpose of the analytic strategy is to link your case study data to some concepts of interest, then to have the concepts give you a sense of direction in analysing the data". Yin (2014) suggested four general strategies which can be used to analyse data in case study method. The four strategies are: relying on theoretical propositions, working your data from the "ground up", developing a case description, and examining plausible rival explanations. In addition to the previous strategies Yin (2014) added that the researchers can develop their own strategy of analysis. This research adopted "working the data from the ground up" as an analysis strategy. It is considered an inductive strategy where the key concepts emerge from the data; not from the theoretical propositions.

3.6.2.2 *Analytic technique*

The second step in conducting robust analysis of the data is detecting the analytic technique. There are five case study analysis techniques which are suggested by Yin (2014) to deal with the lack of systematic analysis procedures problem. The five analytic techniques are pattern matching, explanation building, time-series analysis, logic models, and cross-case synthesis. As a result of choosing "working the data from the ground up", this research adopted a grounded theory as an analysis technique and chose the Charmaz (2006) technique of qualitative analysis. The Charmaz (2006) technique consists of two main phases of coding: initial coding and focused coding.

Coding in this context is a process where a part of the data which could be a word, line, paragraph, or page is given a label or a name that describes the meaning and reflects the action in that part of the data (Charmaz 2006). The initial group of codes were created based on the conceptual framework. Each relevant passage of text from the interviews was added to the suitable code and new ones were created as needed.

As the qualitative and semi-structured interviews chosen for this research provide rich data, the Nvivo 10 software is used to help in the coding process to manage data (Bazeley 2007).

Initial coding

Initial coding involves "naming each word, line, or segment of data" (Charmaz 2014, p.113). The initial coding is called open coding where the researcher does not restrict himself/herself to any previous propositions - rather is open to any new meaning which appears while reading the data. Thus, the initial coding should be connected to the data (Charmaz 2014).

- **Type of initial coding**

The researcher can carry out the initial coding in different ways based on the amount of data that has been coded which is called the "unit of data". The initial coding can be done using word-by-word, line-by-line or incident-with-incident coding. Each type of coding serves particular purposes. Word-by-word coding is useful when the researcher wants to focus on the meaning from the participants' points of view. Line-by-line coding is particularly useful to break down the incidents to parts and understand how they occur. Finally, incident-with-incident helps to find patterns and contrasts (Charmaz 2014).

This research adopted the incident-with-incident type for initial coding because incident-with-incident coding does not cut the codes from their context and thus prevents the codes' loss of the meaning. For example, the incident-with-incident coding is suitable to capture the participants' experiences and attitudes which otherwise may be hard to understand from a word or a line as it usually comes as a story.

- **Usage of comparative methods**

A comparative method seeks to "compare data with data to find similarities and differences" (Charmaz 2014, p.132). No matter which unit of data has been used in the initial coding stage, the purpose of comparative methods is to challenge the researcher's understanding of the data and test the emergent ideas. This process can take several forms depending on the research analysis goal. Thus, comparison can be done by comparing data with data within the same individual's interview or in different interviews. Also, it can be done by comparing data of earlier and later interviews for the same individual (Charmaz 2014).

Figure **3.3** represents the initial codes after coding the interview of Case_1.

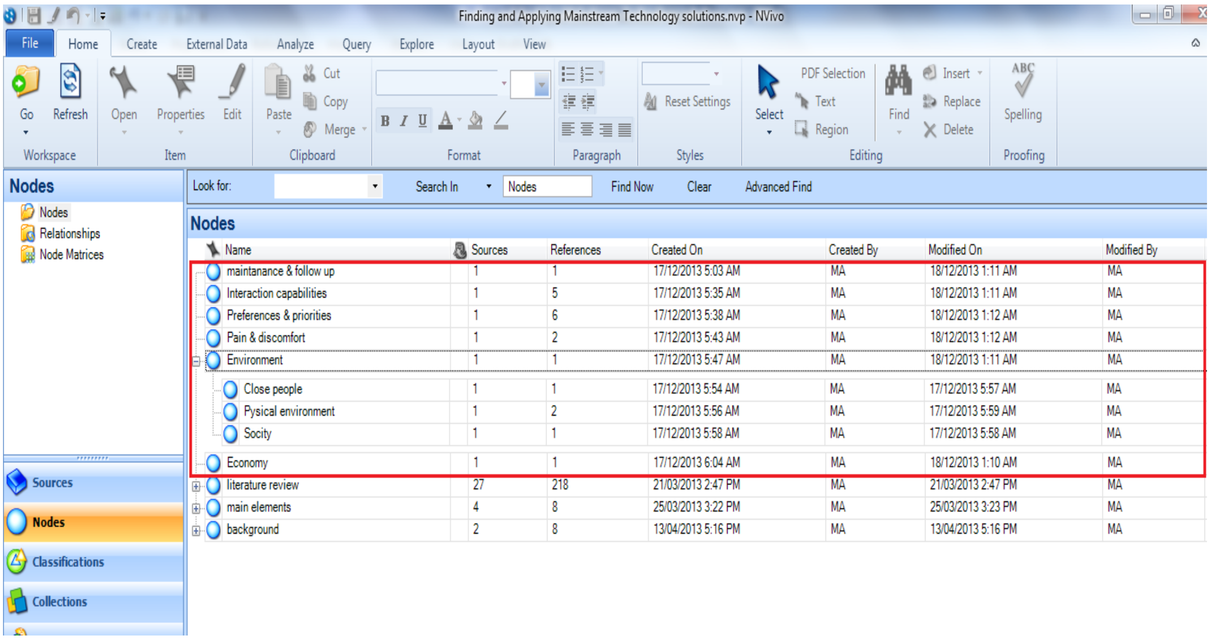

Figure 3.3. Nvivo screenshot of the nodes from Interview 1 of Case_1

Figure **3.4** represents the evolving of codes after coding the interview of Case_2.

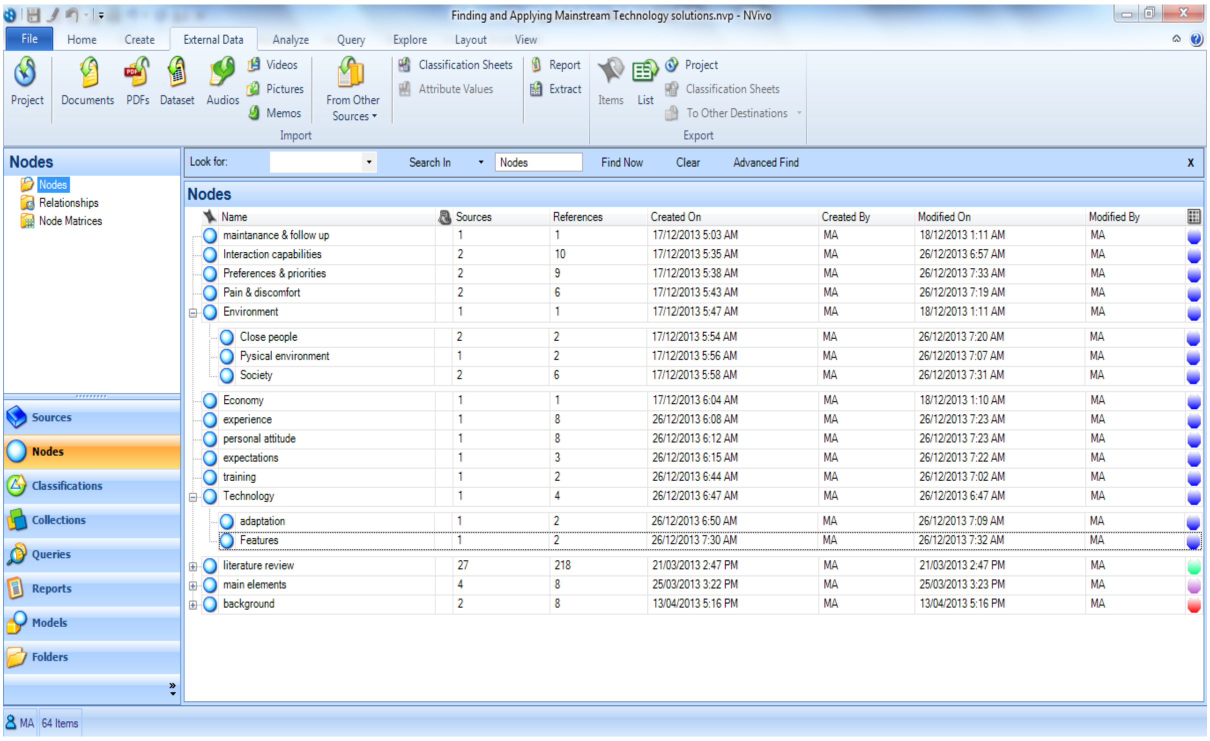

Figure 3.4. Nvivo screenshot of evolving codes after coding Interview 1 of Case_2

Focused coding

Focused coding is the second phase of coding in the Charmaz (2006) process of qualitative data analysis. In focused coding the researchers "sift, sort, synthesize and analyse large amount[s] of data" (Charmaz 2014, p.138) which are already coded in initial coding phase. The purpose of the focused coding phase is to highlight the most important codes created in initial coding and categorize them to improve the analytic sense by generating "the adequacy and conceptual strength of your initial codes" (Charmaz 2014, p.140). Moreover, focused coding can be used to check the previous ideas about the topic.

Figure **3.5** represents the first attempt of sort and synthesis the codes from the initial coding phase.

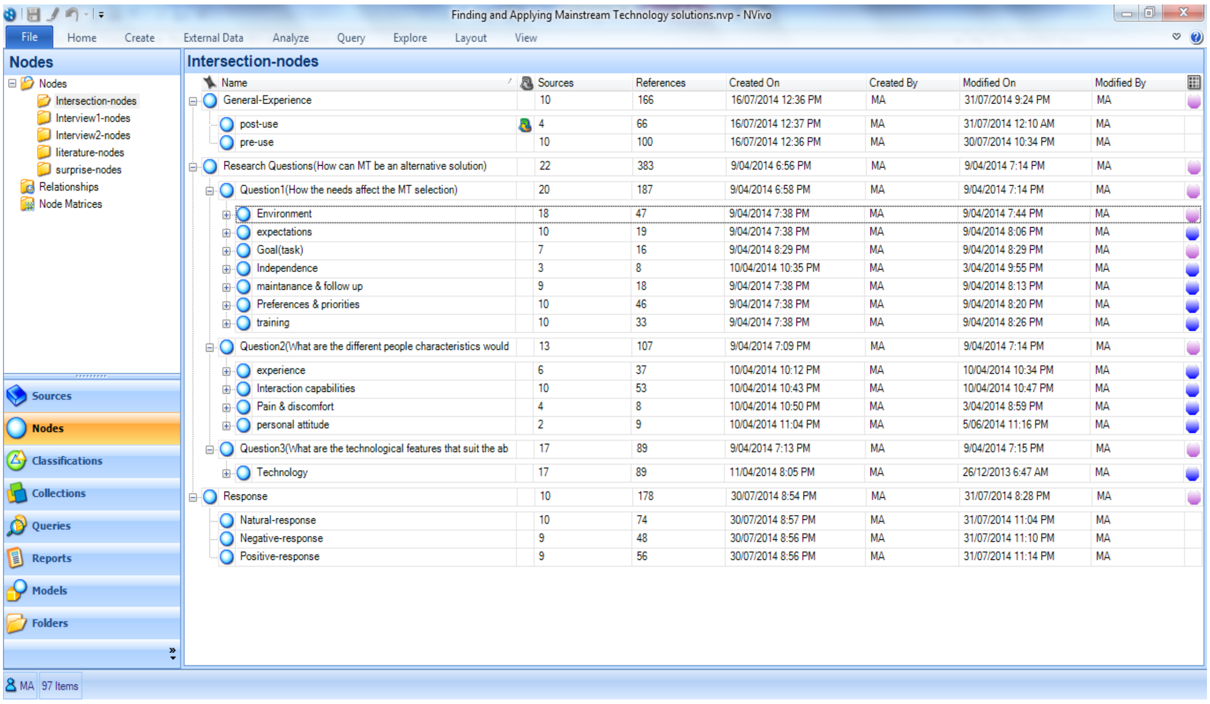

Figure 3.5. Nvivo screenshot of the first phase of focused coding

Figure **3.6** represents the evolution of focused coding after completing all participants' interviews.

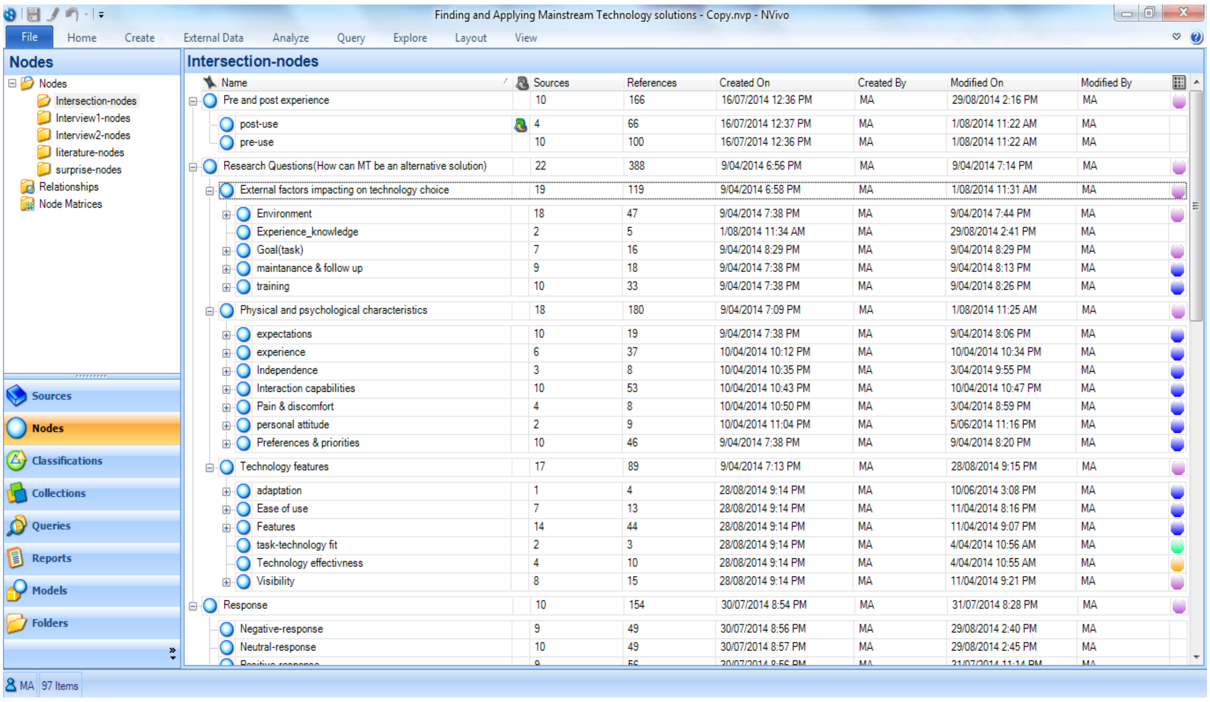

Figure 3.6. Nvivo screenshot of focused coding evolving after completing participants' interviews

The next section presents evaluation of the MTSF which is the last phase of the research process.

3.7 Evaluation stage

The purpose of the evaluation stage was to explore the effectiveness of the mainstream technology selection framework from the specialist's point of view. This stage included qualitative interviews with specialists from Saudi Arabia. The questions were at a high level and focused on the usefulness of the MTSF, any omission of important concepts, and the strengths and weaknesses of the MTSF. Before conducting the interviews with specialists, a booklet containing an overview of the MTSF, a copy of the MTSF components with a description of each one and how they work collectively, as well as the interview questions, were provided to the specialists.

The specialists were selected according to their role in technology recommendation for their clients. In other words, if the specialists had a role in the process of selecting a technology for clients they were chosen to participate in the evaluation questionnaire and interview. Two specialists participated in the evaluation stage. The first one was from Belgium and the second specialist was from Egypt. However, both of them were working in governmental hospitals in Saudi Arabia during the time of the research. See Section 8.2.1 for more information about the specialists and their experience.

The data collected from the specialist's interviews was analysed. Then the results were used to refine the mainstream technology selection framework.

3.8 Limitation of the method

The method adopted for this research was the case study. This section presents some of the limitations associated with this method. While all methods have their advantages and disadvantages, the researcher tried to reach a balance between them in order to achieve the research goal.

One limitation of the case study method is lack of rigor which is mentioned by Yin (2009). He attributed the cause to the lack of systematic procedures to conduct case study research. The absence of analysis techniques that the researcher can follow is due to the early adopters of the case study method who did not present adequate details about the analysis procedures (Yin 2009). Although the lack of systematic procedures of the analysis technique is considered a difficulty especially for novice researchers, it could be an advantage as well. This can give the researcher more flexibility to adopt an analysis technique to help the researcher interpret and explain results. This research used grounded theory as an analysis technique which will be explained in the next section.

Another limitation is that we cannot generalize from a single case (Flyvbjerg 2006; Yin 2009). Addressing this concern requires understanding the difference between two types of generalization. First, in statistical generalization "each case represents a sampling point from some known and larger population" Yin (2012, p.18). Second, in analytic generalization the theoretical framework can be generalizable to other contexts or situations (Yin 2012). Yin (2009, p.15) explained the goal of generalization in case study research and its relationship with theories "case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study, like the experiment, does not represent a "sample", and in doing a case study, your goal will be to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization)". As a result, analytic generalization is the appropriate type for the case study approach (Yin 2012). In this research, the generalization goal is to be able to expand the theoretical framework (Chapter 4) to be applicable in other contexts as will be explained further in the conclusion (Chapter 10).

3.9 Ethical issues

This research gained approval from Monash University’s Ethics Committee. The participants received an explanatory statement after giving their initial consent to be interviewed. The explanatory statement explains to the participants the nature of the research and what tasks they will participate in and their right of withdrawing from the research. On the day of each participant’s interview, they were asked to sign a consent form for the interview to be taped. All results were anonymized to protect the participants’ identities.

3.10 Conclusion

To sum up, the research design chapter presented and justified the research approach, method, and techniques of data collection and analysis. In terms of the research approach this research adopted the qualitative approach with an interpretive paradigm. The method that has been used was the case study. The technique of data collection contained semi-structured interviews with open-ended questions. The interviews and other instruments that were used in the data collection were developed and designed based on the implementation of the activity theory in the disability context. Finally, the data analysis was conducted using the grounded theory as an analysis technique. The Charmaz model of grounded theory analysis was adopted to analyse the data and present the findings. The evaluation stage was used to ensure the validity of the mainstream technology selection framework and produce the final version. The next chapter starts by presenting the literature of the factors that affect the use of the technologies by people with disabilities. The identified factors are the first step of developing the conceptual framework of this research, which is described in detail in the next chapter.

Chapter 4

Conceptual Framework

4.1 Introduction

This chapter describes the process taken by the researcher to develop the conceptual framework. The purpose of the process was to identify and group the factors that affect the use of the technologies by people with disabilities. Then, the relevant theories were reviewed to identify a suitable theoretical foundation.

The process started by reviewing the literature about the factors that affect (positively or negatively) the use of technology in general within the disability context. Then the identified factors were classified and grouped to find out the core and high-level factors: the person, technology, environment, and goal. The next step in the process was reviewing the theories that can define these core factors and the interactions between them. Then the activity theory was chosen to be the theoretical framework for the research. The conceptual framework was developed by redefining the concepts of the activity theory based on the factors that affect the use of the technology. Figure **4.1** shows the steps of the process.

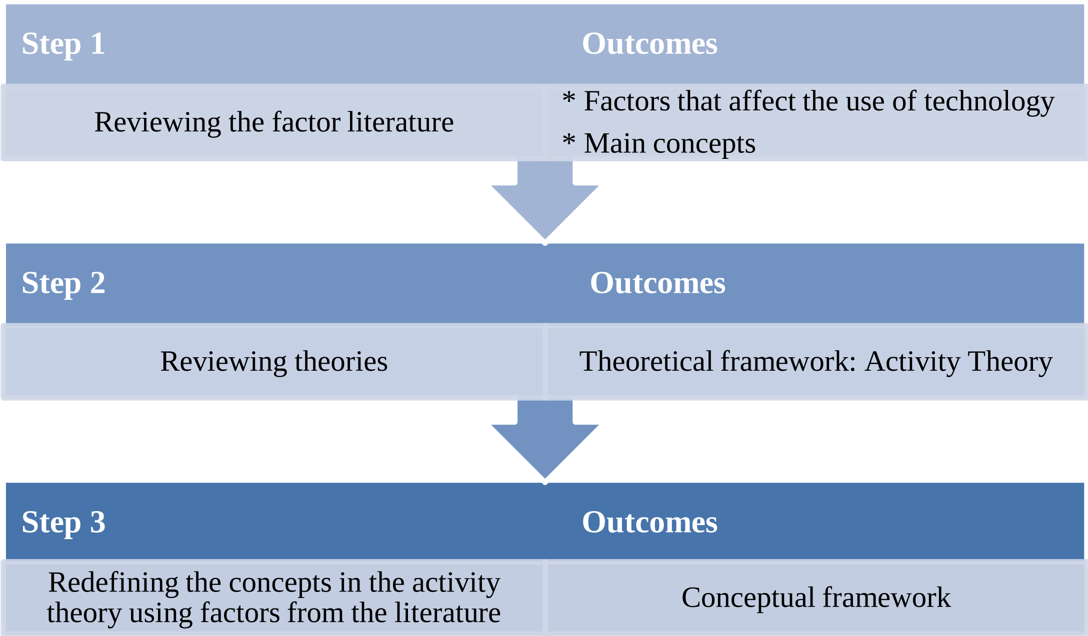

Figure 4.1. The process of developing the conceptual framework

4.2 Factors that affect technology use

Identifying the factors affecting the use or non-use of the technologies by people with disabilities is an important step in gaining a rich understanding of the concepts that must be considered when selecting a technology for a person with a disability. These factors are important to redefine the activity theory concepts in relation to disability context and the use of technologies. The factors come from the wider literature but we have selected specific factors of importance for matching mainstream technologies.

To identify the factors that affect the use or non-use of technology in the literature that has been reviewed fitting all of the following criteria:

- The work represented the factors that affect the use or non-use of the technology.
- The work considered participants with either physical disabilities or no specified disability type.
- The work examined studies using either electronic technologies or no specified technology type.
- The factors were identified directly by the participants.

The literature that was used to identify the factors is listed in Table **4.1**.

Table 4.1. List of the factors references identifying the type of technology and disability in each reference

References	Study Technology	Study participants	Study findings (factors)
(Scherer & Glueckauf 2005)	Not specified	People with disabilities	• Compatible design • Individual abilities • Environment • Team approach
(De Jonge & Rodger 2006)	Multiple types of technologies	26 assistive technology (AT) users having a range of physical impairments	• Ease of use • Pain and discomfort • Resources • Changes considered • Environment • Functional applications • User training
(Copley & Ziviani 2005)	Not specified	Children with multiple disabilities	• Goal (need) • Interaction with technology • Observation of functioning • Individual abilities • Plan implementation and evaluation • Resources • Task analysis • Environment • Functional applications • Team approach
(Priest & May 2001)	Laptop computers	Children with learning disabilities, cerebral palsy, muscular dystrophy, mild physical disabilities. Parents, teachers, school services officers (SSO), occupational therapists, and other professionals involved with laptop prescription.	• Goal (need) • Plan implementation and evaluation • Resources • Considering changes • Environment • Team approach
(Riemer-Reiss & Wacker 2000)	Multiple types of technologies	Multiple types of disabilities	• Involvement of the user • Relative advantage
(Goette 1998)	Voice recognition technology	Multiple types of disabilities	• Individual abilities • Task-technology fit • Environment • Trial-ability • User training

References	Study Technology	Study participants	Study findings (factors)
(Scherer et al. 2007)	Not specified	People with disabilities	● Knowledge and information ● Priorities and preferences ● Relative advantage ● Resources ● Culture ● Expectation and attitudes of others
(Seymour 2005)	Information and communication technology	People with disabilities	● Priorities and preferences ● Resources ● Expectation and attitudes of others

An explanation and more detail of factors will be in the next sections.

4.2.1 Assessment elements

The assessment elements include all factors that technology specialists should consider during the assessment process before recommending a new technology for individuals with physical disabilities. The assessment process for these elements involves the evaluation of all aspects that affect the selection of the technology and how they contribute to the final decision. The assessment elements include the goal and personal factors as described below.

4.2.1.1 *The goal*

The achievement of the goal is related to the achievement of the task (Copley & Ziviani 2005) that an individual wants to accomplish by using specific technology. Identifying the goal in the early stage of the assessment process is an important step since the remaining elements depend on the initial goal and the analysis of the possible ways to achieve it. In addition, the purpose of identifying the goal is to limit the alternative options that the technology specialists should consider when finding appropriate technology (Copley & Ziviani 2005). The person's needs, the family circumstances, the economic situation and the social norms all shape the goals (Higginbotham 1993; Shuster 1993). Establishing clear goals needs a discussion within the team of specialists who assess the person. Once the goals are identified, the assistive technology could be a part of the support plan to achieve the desired goals (Copley & Ziviani 2005). One of the weaknesses of previous models is the failure to identify the goal. The MTSF addresses this issue by starting Interview 1 with several questions to clearly identify the individual's goal (see Section 5.1.1).

4.2.1.2 *Personal characteristics*

Individual abilities

Evaluating the individual's abilities and gathering detailed data about their strengths and weaknesses help technology specialists in recommending a technology that facilitates task performance (Copley & Ziviani 2005; Inge & Shepherd 1995). Today's technologies require a combination of abilities and skills to be used effectively (Scherer & Glueckauf 2005). Thus, assessing physical capabilities such as "muscle strength, range of movement, coordination and gross and fine motor abilities" as well as sensory capabilities is important in deciding on the most appropriate method to access and interact with the technology (Copley & Ziviani 2005; Mann & Beaver 1995). In addition, assessing other skills such as the ability to follow directions and to organize in a daily life setting helps to gather significant information that affects the selection of the assistive technology (Inge & Shepherd 1995). As cognitive, hearing, and vision disabilities are outside the scope of this research, our focus will be on assessing physical abilities. Hearing and vision will be assessed in terms of the degree of strength, rather than terms of availability. See Interview 1 in Section 5.1.1 for a detailed table of the assessment of individual abilities.

Knowledge and information

The knowledge and information that people with disabilities already have about available options plays a crucial rule in their choices and acceptance of the assistive technology (Scherer et al. 2007). People with disabilities can be divided into three groups in regard to knowledge and information about assistive technology:

- People born with disabilities.
- People who have acquired disabilities suddenly as a result of injuries.
- People who have developed their disability gradually.

People who were born with disabilities have a high rate of acceptance of technologies because each opportunity opens access to the world for them. For example, people born with cerebral palsy who are given the opportunity to speak for the first time using synthesised-speech appreciate this and are less likely to reject the technology. On the other hand, people who have acquired disabilities find it difficult to cope with assistive technologies because they can be of the opinion that nothing can replace the real function that they have lost. The third group, who have disabilities gradually develop, have a high rate of rejecting assistive technologies as their needs change over time (Wessels et al. 2003; Scherer et al. 2007).

Ensuring the early capture, within the assessment process, of the knowledge and information that people with disabilities already have about technologies gives the technology practitioners insight about potential technology acceptance. Thus the MTSF is structured to capture this information in Interview 1 (see Section 5.1.1).

Preferences and priorities

Preferences and priorities differ from person to person and even over time for the same person. Preferences and priorities are significant factors that influence the decision of the assistive technology (Judge & Parette 1998). Preferences and priorities are influenced by self-determination and self-confidence, which are formed by past experiences. Past experience with assistive technology influences the preferences and priorities of people with disabilities. These preferences and priorities relate to assistive technology features, the main usage goals, their environment, and how long individuals want to spend using the assistive technology (Seymour 2005; Scherer et al. 2007). MTSF takes special care of the preferences and priorities of the person with disability and asks questions regarding the preferred interaction method, the preferred access technology and the preferred features of the technology. This information is collected in Interview 1 to ensure that the most appropriate access technology is chosen, although the literature lacks detail on the execution of the selection (Copley & Ziviani 2005).

Relative advantages

Relative advantage (or cost-benefit according to some literature) is strongly related to the continued or discontinued use of assistive technology (Riemer-Reiss & Wacker 2000). Across all groups and ages, the assistive technology advantages sought by people with disabilities are: comfort (Riemer-Reiss & Wacker 2000; De Jonge & Rodger 2006), effectiveness, reliability, ease of use, and enhancement of the user’s performance (Carroll & Phillips 1993; Riemer-Reiss & Wacker 2000; Copley & Ziviani 2005). Furthermore, when cost-benefit issues are considered including customisation, installation, repairs, training and follow-up, there is an increased chance of continued use. The MTSF considers the cost-benefit issues in Interview 2, Section 5.1.4.

4.2.2 Involvement of the user

Riemer-Reiss and Wacker (2000) state that involving the people with disabilities in the process of technology selection improves the likelihood of adoption as the individual feels that s/he has the control of his/her choices. The involvement of the user includes trying the assistive technology, gathering information about the assistive technology by talking to other users, and being aware of the available options (Wessels et al. 2003; Martin et al. 2011a). Martin et al. (2011a) added that involving the person with disability in the selection of the assistive technology decreases the chance of rejection and dissatisfaction. Involvement of the user includes providing adequate information about the available options of the assistive technology to the person with disability. Next, careful assessment of the interaction between the person, the assistive technology and the environment is required. This is followed by the person with the disability trying the assistive technology before buying it. Finally, a follow-up evaluation is required to ensure that the assistive technology still works properly and is still needed (Martin et al. 2011a). The MTSF enables involvement of the user by discussing the person, assistive technology and environment issues with the person in Interview 1. See Section 5.1.1 for more information about the individual's abilities, assistive technology features and the environment.

4.2.3 Resources

Resources include all issues that support continuance using the AT. The resources are divided into human, material, and financial resources. Human resources include staff who can provide technical support and training. Material resources include hardware and software (Copley & Ziviani 2005). Financial resources include the funding for the assistive technology itself (Scherer et al. 2007), the cost of technical support, and training (De Jonge & Rodger 2006). There are other resources not included in the above categories such as time (Copley & Ziviani 2005). The individual with disability should be given adequate time for involvement in the technology selection process, training, and learning to transfer from the current way of doing tasks to the use of the selected technologies. As the technology solutions in this research are from mainstream technologies, the resources are not considered an obstacle. In comparison to the assistive technologies that are specifically designed for people with disabilities, the mainstream technologies are more affordable.

4.2.4 Characteristics of the technology

4.2.4.1 *Compatible design*

Compatible design means that the technology has to be compatible with the person's needs and also with other technologies already in use by this person. To meet one need or goal of the person with the disability we should also consider other needs. For example, if the person with disability needs a small and portable reminder device, the technology practitioner should consider his/her vision and fine motor abilities in order to enable the person to use the device effectively. However, it is important to consider the direct correlation between the number of assistive technologies that the person concurrently uses and the abandonment rate. Using a minimum number of assistive technologies concurrently leads to less abandonment (Wessels et al. 2003; Scherer & Glueckauf 2005). The MTSF takes into account the current use of any assistive technology. In addition, the MTSF gains benefit from any advantages or disadvantages in the current use in order to provide a better experience with the recommended technology. See Interview 1 (current situation section), Section 5.1.1.

4.2.4.2 *Ease of use*

Whenever assistive technology is easy to use, it is likely to be used more often. Maintaining a balance between simplicity and meeting a person's need encourages the person with disability to continue using the assistive technology. On the other hand, the complexity of assistive technology features leads people with disabilities to be frustrated and then to discontinue use of the assistive technology beyond the basic features (Wessels et al. 2003; De Jonge & Rodger 2006). The MTSF considers ease of use an important factor. Several questions on the perceived ease of use of the recommended technology are included in Interview 2 (see Section 5.1.4).

4.2.4.3 *Stigmatization*

Stigmatization refers to the feeling of the people with disabilities of being vulnerable and different from the general population. Moreover, using visible assistive technology that attracts other people's attention increases the feeling of stigmatization and leads to abandonment of it (Parette & Scherer 2004). Thus, paying attention to the physical design of the assistive technology enhances the self-confidence of the person who uses the assistive technology. Shinohara and Wobbrock (2011) reported that people with disabilities were aware of the differences between their assistive and mainstream technologies. They further asserted that the look of an assistive technology can affect its adoption. Shinohara and Wobbrock (2011) suggested mainstream technologies or at least assistive technologies that looked normal in terms of physical design as a solution to this stigmatization problem. This is a goal we intend to achieve in this research by offering mainstream technologies as alternative solutions for people with disabilities. The MTSF addressed the issue of stigma in Interview 1 when asking about the preferences of the person in terms of the technology being visible or inconspicuous, and also about the features of the technology. See Section 5.1.1.

4.2.5 The environment

The environment where the people will use the assistive technology is an important factor to consider before obtaining the assistive technology. Many issues related to the environment could affect the use of the assistive technology such as physical barriers, the background noise, the light, and other people. Overcoming the environmental barriers helps the people with disabilities to use their assistive technologies in public places as much as they use it in their private life, allowing them to be more social. There are many methods which assist detection and solve environmental issues such as giving people with disabilities the opportunity to try and use the assistive technology in the actual environment. In addition, strong support and positive attitudes from the caregiver, social environment, and close family members enhance the desire for using the assistive technology (Goette 1998; Wessels et al. 2003; Copley & Ziviani 2005; Scherer & Glueckauf 2005; Seymour 2005; De Jonge & Rodger 2006; Scherer et al. 2007). The environmental issues are given special consideration in the MTSF during Interview 1 and Interview 2. Interview 1 gathers information about where the technology will be used, for how long and in which position. Interview 2 follows up the environmental issues by checking whether or not the technology has been used in the intended environment and by identifying the obstacles related to non-use (see Section 5.1.1 and 5.1.4).

After identifying the factors relating to technology adoption from the literature, they were grouped and classified as core factors and sub factors. These are represented in Figure **4.2**.

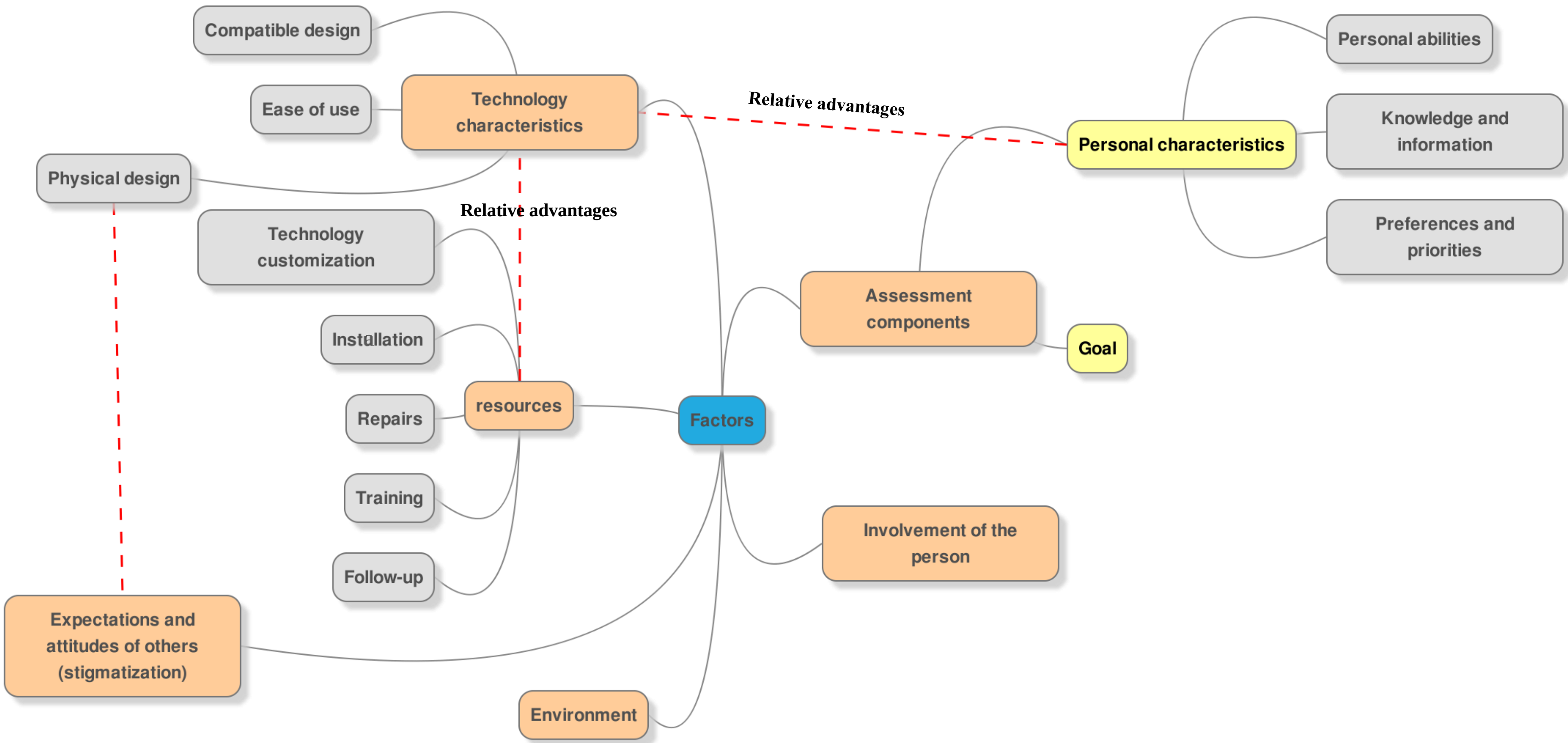

Figure 4.2. Factors that affect the use or non-use of technology in a disability context

4.3 Adopted theoretical framework

As illustrated in Figure **4.2**, the factors that affect the use of technology are assigned to the following categories:

- The person who will use the technology to perform an activity
- The technology itself
- The needs (goal) of the person
- The environment where the person will use the technology.

These concepts interact to help fulfil the needs of the person by completing the desired activity. The concepts of my research and how they interact directed my choice of theoretical framework. I have investigated theories from different disciplines. The following sections will give an overview of each theory and its applicability to this research.

4.3.1 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB) from social science focuses on the reasons that motivate people to perform or not perform health practices (Ajzen 1991). Generally, the TPB measures people's intentions to engage in certain behaviour. Thus, it is mostly used to shape social beliefs (Parmar et al. 2009). The TPB covers behaviour beliefs, which are the subjective probability that the behaviour will give an expected result; normative beliefs, which are the motivations to engage in behaviour; and control beliefs, which include all factors that make accomplishing the behaviour easier. Even though the TPB offers sufficient details about factors that surround the person and measures the extent to which a person is affected by these factors, such as personal, demographic, and environmental factors. Regardless of whether these factors are direct or indirect, the TPB does not give the technical side of the technology's features or the interaction between the person and the technology enough consideration. Since my research focuses on the best way to match people with disabilities with mainstream technology that considers their abilities to facilitate the meeting of their needs, I chose not to make use of the TPB.

4.3.2 Affordance theory

On the other hand, the affordance theory addresses the properties of an object and the importance of making the object's affordances perceptible. This helps in designing an easily used system. The affordance theory considers the culture, experience, learning, social setting and intentions as indirect factors that are not integrated into the affordance concept (Gaver 1991). As shown in Figure **4.3** the affordance theory was built based on the distinction between the real affordances of the object and the available information about those affordances. This distinction comes with a hidden affordance term that refers to the case in which the affordance is available but the perceptual information about it is missing.

Figure 4.3. The affordance theory (Gaver 1991)

This situation represents one of the reasons that people with disabilities do not get the benefit of the technologies that already they have. They have stated that they are not aware of all the properties (affordances) that their technologies could offer them. Making technology properties perceptible for people with disabilities will not address my research problem properly because it represents only one part of the problem. The second and more important part, in my view, is helping people with disabilities to recognize their abilities and match them with suitable technology properties to fulfil their needs. This requires a framework that considers all these concepts, the interaction between them, and internal and external factors that affect the matching process. The matching cannot be achieved by the affordance theory alone.

4.3.3 Activity theory

The activity theory is mix of the ideas of three scientists, Rubinstein (1963), Leontiev (1977), and Vygotsky (1978) (Hevner et al. 2004). The activity theory is a conceptual framework that considers an activity as a unit of analysis (Figure **4.4**). The activity unit consists of a subject (person with physical disability), an object (intended activity), and a tool (device by which the action is executed) (Hashim & Jones 2007). Thus, the activity unit can be defined as an object to be achieved by a person using a tool. The activity theory is a practical lens to analyse complex human research (Hashim & Jones 2007). In addition, the activity theory helps the researchers to direct their research about a complex problem and determine the right questions to ask about the phenomena under study (Rogers 2004; Kaptelinin 2013).

Figure 4.4. The extended version of activity theory (Engeström 2001)

The activity theory can be used to discover the interaction between the concepts that might play crucial rules in selecting and using mainstream technology for people with disabilities. As a high level activity theory gives researchers the freedom to apply it in different contexts by redefining the main concepts as long as they follow basic principles. These basic principles are introduced in the next sections.

4.3.3.1 *The basic principles of activity theory*

Hierarchical structure of activity

The activity unit in the activity theory is divided into three levels: the activity itself, actions, and operations (see Figure **4.5**). The activity is directed by motivation. The actions can be done to fulfil one or more goals. Finally, the operations do not have any specific goals. Instead, one or more operations represent one action, and these operations can be changed depending on the change in conditions in each context (Kaptelinin & Nardi 1997).

Figure 4.5. Hierarchical structure of activity (Kaptelinin 2013)

Object-orientedness

To understand the objectives that motivate human activities, it is necessary to consider not only the physical objects that the person deals with in the real environment but also the social and cultural properties of that environment. Thus, an analysis of the activity as a separate unit without considering the changed conditions around that activity in the environment will not reflect the reality of human life (Kaptelinin & Nardi 1997; Kaptelinin 2013).

Internalization/externalization

Internalization and externalization refer to the dynamic mutual process between the internal and external components of the activity. Generally, internalization refers to mental activity, such as when a child transfers from doing math using his hands to doing it mentally, which represents the transformation from an external activity to an internal activity (internalization).

Externalization refers to a transformation from internal to external components of activity, such as drawing a design prototype on paper to share or modify.

It is hard to understand the activity unit without considering both the internal and external components of that activity and the mutual process between these components. The individual/social idea is similar to an internal/external idea, which makes the activity theory applicable in real life, where individual activities are affected by social activities and vice versa (Kaptelinin & Nardi 1997; Kaptelinin 2013).

Mediation

One of the important principles of the activity theory is mediation, which involves the third and intermediate connector (tool) that stores information about the relationships between the other concepts. For example, the subject interacts with the object using the tool as a mediator (Kuutti 1996). The tool is shaped and influenced by external activities as well as internal activities. In a real context, the tools used by humans are shaped by the social and cultural properties and by the mental functioning of the individuals who use it (Kaptelinin & Nardi 1997; Kaptelinin 2013).

Development

The development principle in the activity theory covers both the object of the study and the research strategy. Thus, to achieve a good understanding of the phenomena, studying the development of the object's changes and analysing the phenomena at different levels is important (Kaptelinin & Nardi 1997; Kaptelinin 2013).

Furthermore, as the environment is a significant factor in the interaction between the person and the technology to achieve certain goal, the theoretical framework of this research is based on the extended version of activity theory which appeared in (Engeström 2001). The choice of the activity theory comes from it being applied in many studies in the human computer interaction (HCI) field, such as (Kaptelinin 1996; Collis & Margaryan 2004). In addition, the activity theory considers the main concepts of the phenomenon under study, which are the subject (person), the tool (technology), community (environment), and the object (activity). Furthermore, it supports the interpretive and qualitative research methods (Hashim & Jones 2007). Even though being a high level theory is considered as an advantage, it is considered as a limitation in this context because it gives the researchers the freedom to redefine the tool concept but at the same time it does not give sufficient details about how the tool concept will be redefined. The redefinition will be given more consideration in this research study. This limitation was mentioned by Kaptelinin (2013), who stated that the activity theory is a high-level conceptual framework that was not specifically developed for particular types of tools. He added that the activity theory has required efforts from HCI researchers to adjust to be suitable for specific applications. Rogers (2004) added another limitation: the lack of operational application of activity theory concepts, which also require adjustments for different contexts.

4.4 The conceptual framework

This research focuses on number of concepts, as shown in Figure **4.6**: the subject (person with a physical disability), the object (intended activity), a tool (device by which the action is executed), and the community (the interaction between the individuals and their environment). However, in my research, two concepts in (Engeström 2001) extended version of the activity theory will be excluded. The first excluded concept is the division of labour since my research addresses the individual interaction between a person with a disability and mainstream technology to fulfil the person's needs, so this concept is not needed. The second excluded concept is comprised of rules: sets of conditions that help to determine how and why individuals may act. The rules concept covers service delivery policies, social relations, and culture, which are outside the scope of my research, as the focus is on mainstream technology. The mainstream technologies are not subject to delivery policies or social and cultural relations, as they are accepted and already used by a large segment of society.

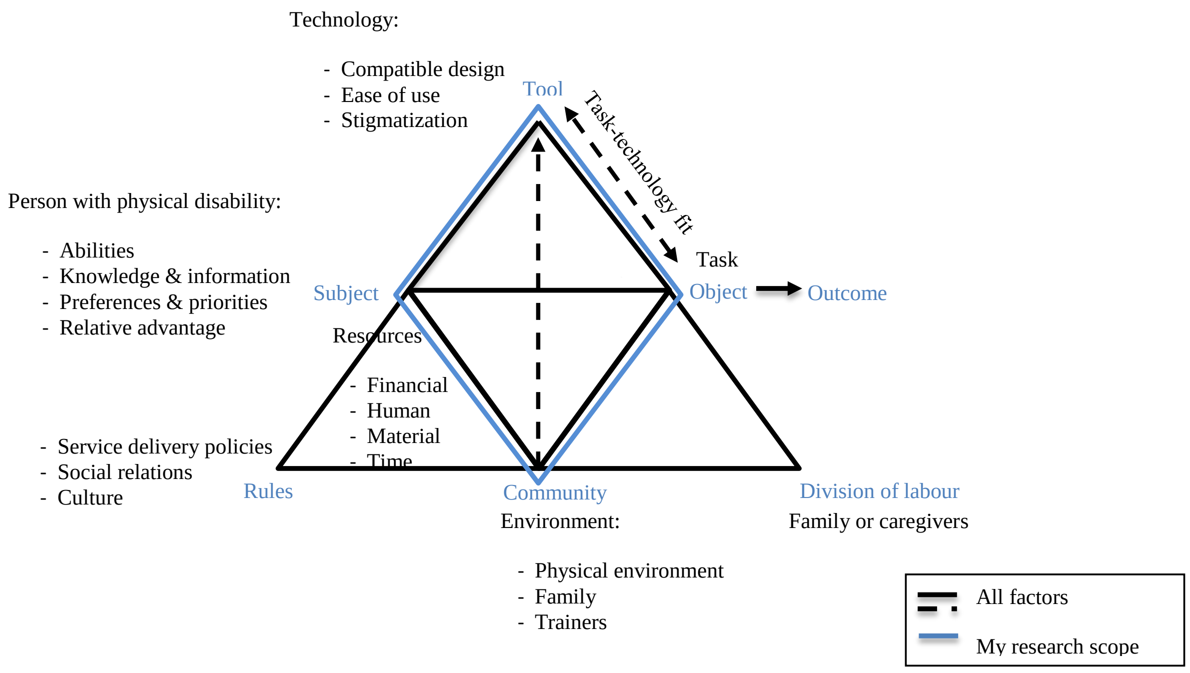

Figure 4.6. The conceptual framework: redefining activity theory concepts by classifying the factors that affect the use of technology under the related concept

I used the activity theory to represent the factors that affect the use or non-use of technology. As shown in Figure **4.6**, the concepts of the activity theory are redefined by classifying each group of factors under a related concept in the activity theory. The themes are developed by merging the factors with the concepts of the activity theory. The instruments of my mainstream technology selection framework are based on these themes which are described in next section.

4.5 Conclusion

This chapter presented the conceptual framework of the research. The first step to developing the conceptual framework was reviewing the literature of the factors that affect the use of the technology in general: either mainstream technologies or the specific technologies for people with disabilities. The second step was reviewing the theories that can provide a solid foundation for the research. The chosen theory was the activity theory for the reasons listed previously. To build the complete picture of the conceptual framework, the activity theory was adapted to accommodate the factors of the technology use from the literature. The next chapter presents the proposed Mainstream Technology Selection Framework (MTSF) which is based on the conceptual framework.

Chapter 5

The Proposed Mainstream Technology Selection Framework (MTSF)

5.1 Introduction

This research has developed a new framework called the mainstream technology selection framework. This framework includes four instruments: Interview 1, a decision tool, a search tool, and Interview 2 (Figure **5.1**). The MTSF is not based on any previous tools or frameworks. However, it gains benefit from the strengths of existing frameworks and overcomes weaknesses (see Section 2.8 for details). The themes in the instruments of the MTSF are based on the conceptual framework. The questions of Interview 1 and Interview 2 were formulated to address the concepts that were identified in the conceptual framework (Chapter 4). The aim of the mainstream technology selection framework is helping technology specialists to recommend the appropriate mainstream technology for people with disabilities. The following sections give an overview of each instrument in the order they are applied.

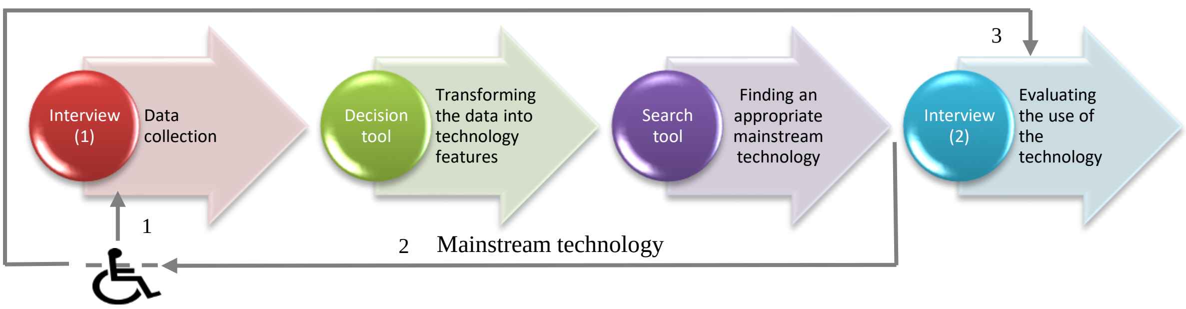

Figure 5.1. Mainstream technology selection framework workflow

5.1.1 Assessment of needs and abilities (Interview 1)

Interview 1 is a semi-structured interview that aims to collect data about three main themes for use in the decision tool. Interview 1 questions are asked by the practitioner to the person with the disability. The three themes: task, person, and environment are derived from the conceptual framework (refer to the conceptual framework in Figure **4.6**). The first theme "task" covers the goal that the individual intends to achieve by using technology. The goal from the task theme is to identify the task, analyse the current situation of the individual, and analyse any benefit from past experience regarding the use of the technology. The second theme "person" includes an assessment of the abilities of the individuals in interacting with technology and the preferred interaction methods. The third theme "environment" includes questions about environmental factors such as the place where the individual intends to use the technology, the duration of technology use, the attitudes of the people around the individual who uses the technology, and the physical features of the technology (weight, size, and visibility).

Following is Interview 1 script.

Interview (1): Data collection (step 1)

Name____________________________ Code____________________________

Age______________________________ Contact details____________________

Type of disability___________________

1. Tasks (activities)

Can you suggest at least THREE activities for which you wish you had technology?

I wish there is a technology helps me

____

____

What are the kinds of activities that family members or carers do for you?

____

____

____

____

- Current situation:

How do you currently accomplish the task?

____

____

- Pros and cons of current method:

What are the advantages of the currently used method?

____

____

What are the disadvantages of the currently used method?

____

____

Did you ever use any technology to help you overcome disability limitations?

____

Have you had any problems with technology that supported you in the past?

____

____

2. Personal information

- Abilities

How do you rate and describe your ability in regards to the following interaction capabilities?

*Interaction capabilities scale: 0(None), 1(Poor), 2(Fair), 3(Good), 4(very Good), 5(excellent).

Capabilities	Rate	Description
Vision	……..	…………………………………
Eye control	……..	………………………………….
Audio (speech)	……..	…………………………………
Hearing	……..	…………………………………
Somatic (the ability to sense of touch)	……..	…………………………………
Breath	……..	…………………………………
Head control	……..	…………………………………
Arm control	……..	…………………………………
Shoulder control	……..	…………………………………
Elbow control	……..	…………………………………
Hand control	……..	…………………………………
Finger control	……..	…………………………………
Knee control	……..	…………………………………
Foot control	……..	…………………………………

- Knowledge and information

What level of education do you achieve?

____

Is the disability stable or degenerative?

____

Do you have any experience regarding technology use?

____

- Preferences and priorities

Do you prefer the technology to be visible or inconspicuous?

____

Do you have any preferences in regards of?

Technology size ____

Technology weight ____

Technology features ____

Interaction method ____

Other ____

What is the issue that is highlighted as the most priority for you?

Completing the task perfectly ____

Completing the task in shortest possible time ____

Completing the task with less effort ____

Other ____

- Relative-advantage

Do you think you will get benefits from using technology?

___

What kind of benefits do you think you will get?

___

What kind of problems do you think you will face?

___

3. Environment

Where do you intend to use the technology? (Indoor, outdoor)

___

What are the physical environment factors in the environment you intended to use the technology in?

___

Do the people around you support you to use the technology?

___

How the people around you affect the use of technology?

___

Where do you usually get support to use the technology you already use?

___

___

4. Resources

What is the financial source of the technology?

___

Do you think the cost of the technology have a big impact on your use or non-use?

____

What resources do you have to get help to learn how to use the technology properly?

____

Could you see any benefits from having training sessions on the technology before or during the use of the technology?

____

Are you aware of existing or upcoming solutions to help you achieve your goal?

____

How would the use of such technology fit into your daily routine?

____

How does the use of the technology help you save time?

____

Would you like to add anything?

____

____

____

5.1.2 Decision tool

The decision tool: Figure **5.2** represents the second stage of the mainstream technology selection framework. The aim of this stage is to map the data collected by Interview 1 into technology features. The decision tool is represented by using a decision tree model. The first level is the task, which is the first theme in Interview 1. The task detects the main function of the technology. The second level includes the person and the environment, which are the second and third themes in Interview 1. If there is more than one branch at the same level, the higher priority branches are placed further to the left. The branch that contains the person will take priority, followed by the branch that includes the environment. The data collected about the person's abilities is translated into information on the interaction methods, which includes the input and output methods of the technology. In addition, the decision tree translates the experience of the person in regard to the use of the technology by overcoming the previous disadvantages and benefitting from the previous advantages. In the same way, the data collected about the environment are translated into physical features (size, weight, external design, and visibility) and technical features (battery and screen) to decide whether the person needs additional supportive technologies to accommodate specific environmental factors. See Appendix C for detailed information on how the open ended interviews were transferred to the decision tool.

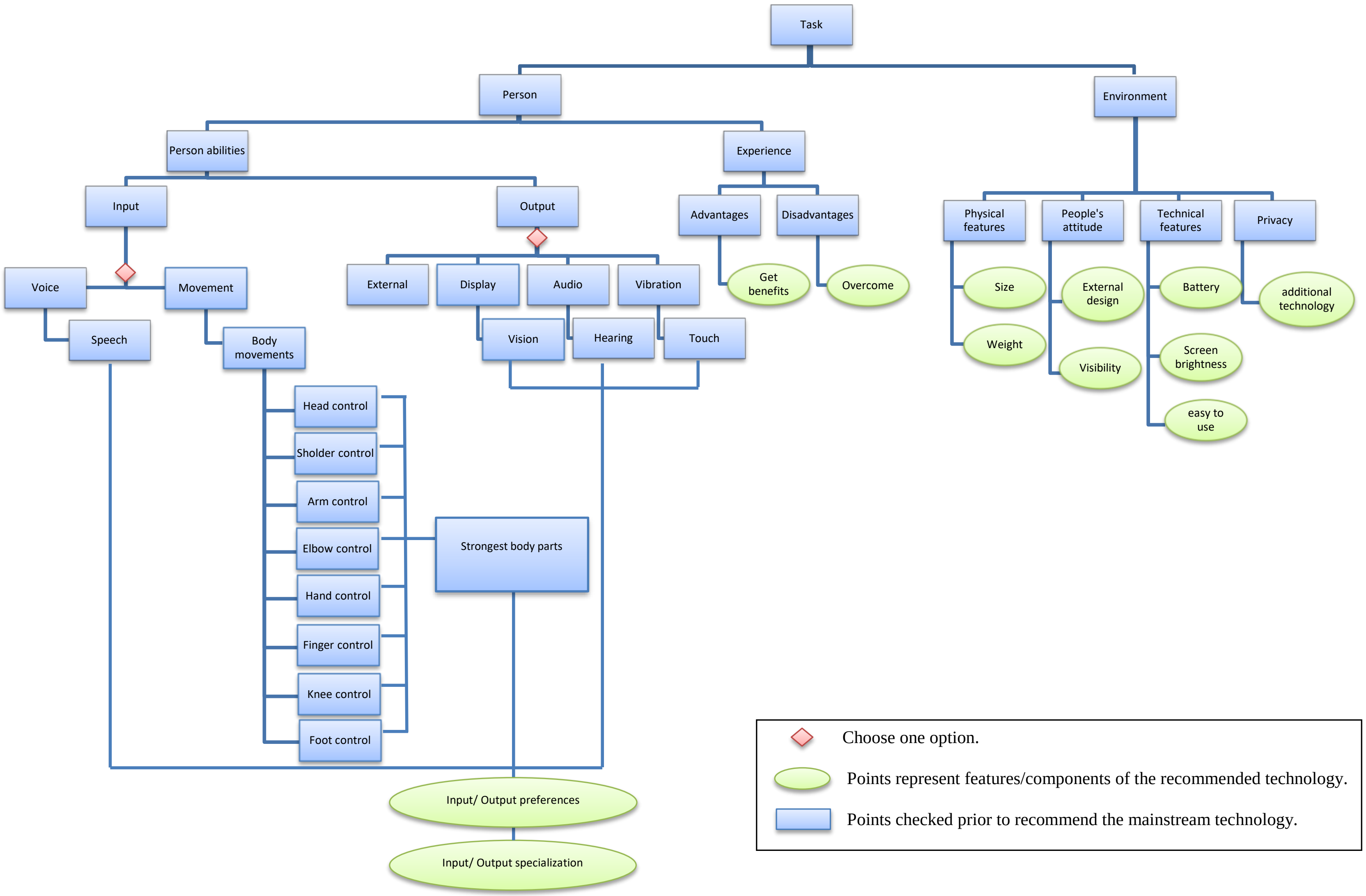

Figure 5.2. Decision tool

5.1.3 Search tool

The search tool (Figure **5.3**) is the third stage in the technology selection framework. A flowchart diagram has been used to represent the process of searching for a mainstream technology using the information generated from the decision tool. I have chosen a flow chart because I want to present the steps of the search for the technology as a process where the next step is based on the result from the previous step. The aim of the search tool is to find mainstream technology through research (for example, via technology magazines, technology databases, or the internet) that meets the person's needs based on the data collected from Interview 1 and processed by the decision tool. The first step in the search tool is to search for the main function of the technology and then to determine whether the technology meets the input and output methods that the person prefers and is able to use. A lower priority will be given to the environmental factors. Thus, after finding a technology that accomplishes the main function and meets the input and output methods, the technology will be checked against the environmental requirements to ensure the ease of use.

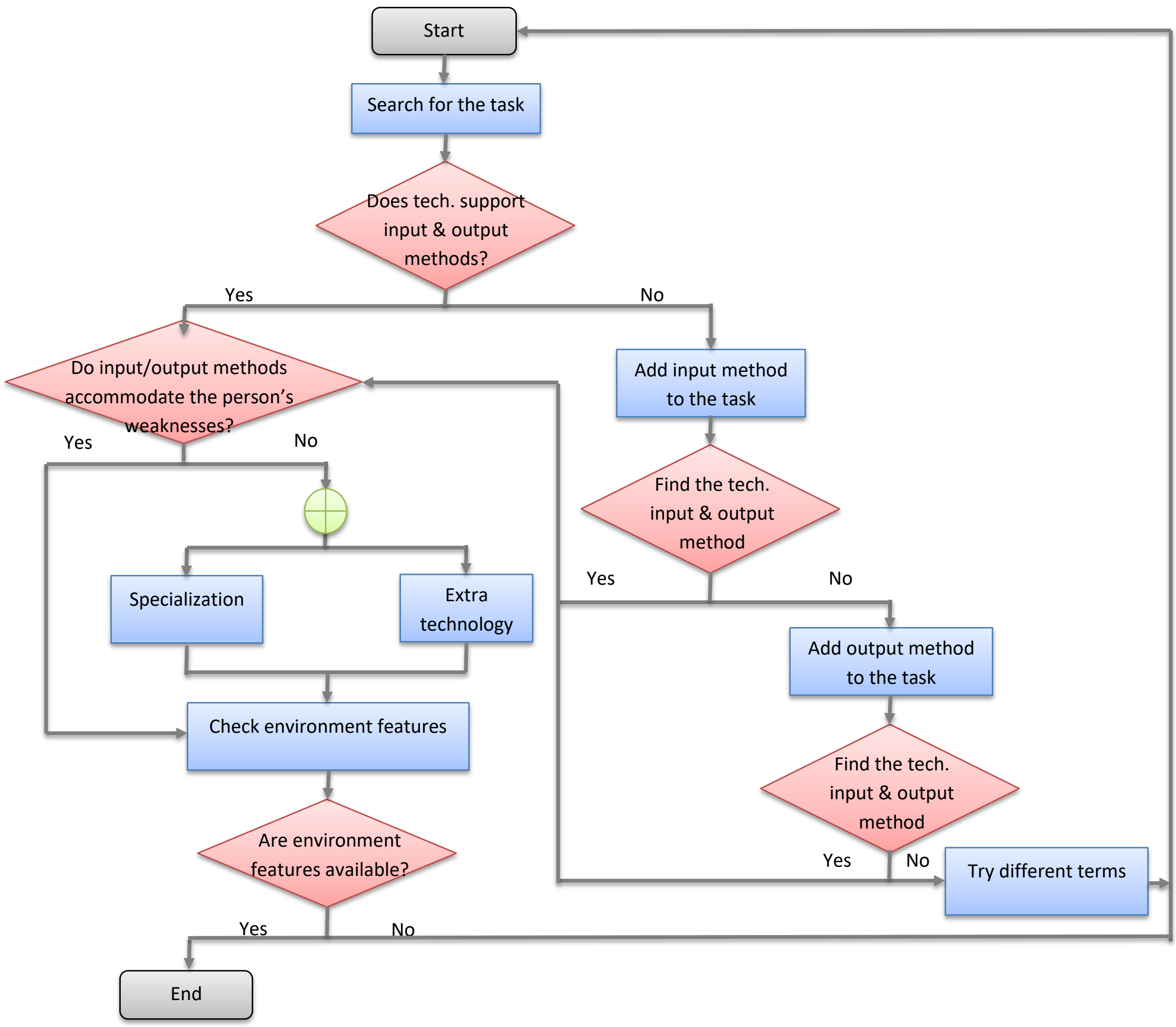

Figure 5.3. The search tool

5.1.4 Evaluation of technology effectiveness (Interview 2)

Interview 2 follows the same structure as Interview 1. Interview 2 is a semi-structured interview that aims to evaluate the effectiveness of the recommended mainstream technology. It includes three themes: the goal, the technology, and the environment.

The goal theme contains questions that measure the extent to which the technology meets the needs of the person and whether the technology has been used to achieve goals that differ from the original goal. The technology theme contains questions related to how easy and comfortable the technology is to use. In addition, it represents the physical and emotional difficulties that were faced by the person during the use of the technology. Furthermore, it includes an evaluation of the physical and technical features of the technology. Finally, the environment theme includes the effects of environmental factors (e.g. light and sounds) and other people on the use or non-use of the technology in the intended environment. Interview 2 is used after the person tries the technology for a period of time so s/he has the required knowledge and experience about how to improve his/her performance using the technology. Interview 2 benefits both the specialists and the person with the disability because they can have a discussion about the difficulties the person faced and work together to overcome them.

Following is Interview 2 script.

Interview (2): Evaluation (step 4)

How the technology works under your circumstances

Technology device: ________________________________

Name: _____________________________ Code: ______

Date of assessment: ________________________________

1. The goal (needs)

What was your goal?

____

Did the technology help you achieve your goal?

____

How effective was your technology (the degree to which the technology meets your needs)?

____

How does the technology overcome the previous difficulties?

____

Do you still need help from family members or carers to do any part of the task?

____

How do you compare the previous method of doing the task and using the technology to do the same task?

____

Were there other things that you used the technology for?

____

2. The technology

What was the technology that you used?

What task were you doing using the technology?

What are the advantages of the technology?

How easy is it to use your technology?

How comfortable is your technology in terms of physical effort?

How comfortable is your technology to use in public places?

What are the difficulties of using the technology?

How does the use of the technology meet your expectations?

How satisfied are you with:

- The dimensions (size, height, length, width) of your technology?

- The weight of your technology?

---

3. **The environment**

Did you use the technology in the environment you intended? If not why?

How the technology overcomes the physical environment barriers?

What kind of support did you receive from the people around you regarding technology use?

How did the opinions of people around you affect continuance using the technology?

4. **The resources**

Does the technology fit in the range of your financial resources?

Do you find the training session enough to help you using the technology comfortably?

What are the advantages of the training session?

What are the disadvantages of the training session?

Did you ever think this technology would help you overcome your disability limitations?

How does the use of technology for doing daily tasks affect your daily routine?

Did the technology help you doing tasks in shorter time?

____

Would you continue use the technology in the future? Why?

____

____

____

____

5.2 Conclusion

The conceptual framework was used to develop the mainstream technology selection framework (MTSF) that was presented in this chapter. A description of each instrument of the MTSF was given including the themes and questions. The next chapter is Phase 1 of the refinement of the MTSF.

Chapter 6

Refinement Phase 1: from MTSF to $MTSF_1$ through Hypothetical Cases

6.1 Introduction

This chapter presents the first phase of refining the Mainstream Technology Selection Framework (MTSF). First, the purpose of conducting the hypothetical cases and the analysis technique are stated. Second, the method is presented. This presentation includes how the hypothetical cases were recruited, a description of the hypothetical cases, and how the MTSF was applied to reach the recommended technology solutions. Third, the analysis of the collected data from interviews is presented. Then, the implications of the applied MTSF along with a discussion of how these implications lead to the next phase of refining of the MTSF is explained. Finally, the $MTSF_1$ (amended version after Phase 1) is presented.

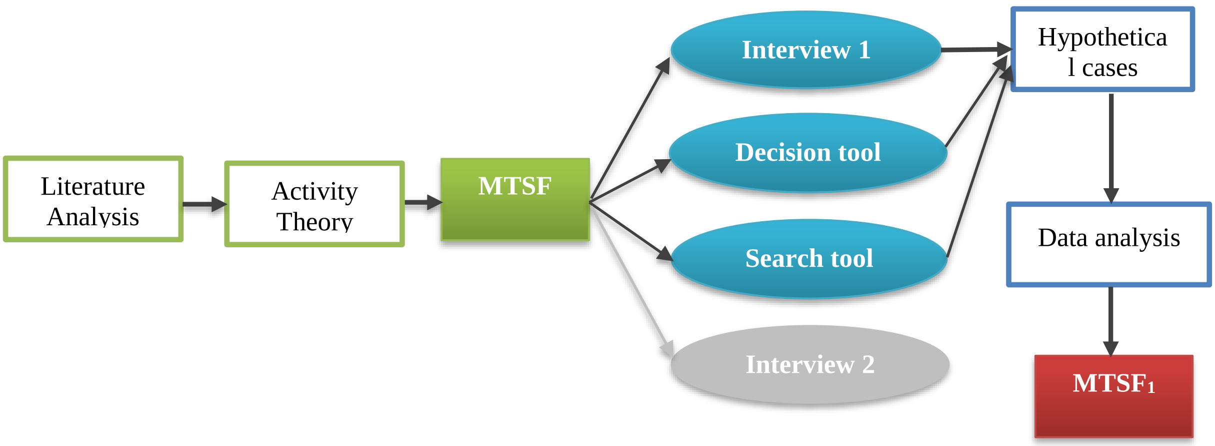

Figure 6.1. Phase 1 of the refinement of the Mainstream Technology Selection Framework (MTSF) by using the hypothetical cases

The purpose of Refinement Phase 1 is to make sure that the right questions were asked in the Interview 1 and to ensure that all of the important information was collected to make an appropriate technology selection. Moreover, Refinement Phase 1 assisted the researcher to measure the effectiveness of the decision tool and search tool to allocate the appropriate technology solution for the participants.

As it is shown in Figure **6.1**, Interview 2 is part of the MTSF however it was not used in Refinement Phase 1. The collected data from Interview 1 was analysed using the Nvivo software. The findings of the hypothetical cases analysis were focused on the value of the collected information and divided into two themes. The first theme comprises the effective responses; the second comprises the ineffective responses. The next section presents a description of the hypothetical cases and the application of the MTSF to find the technology solutions for each case.

6.2 Method

The hypothetical cases were two cases that resulted from the disability expert completing the questions of Interview 1 with hypothetical responses based on her experiences of working with people with disabilities. The researcher ran through the decision and search tool with this data. The following is the description of the two hypothetical cases.

6.2.1 Description of the cases

Table **6.1** shows information about the participants regarding their age, gender, type of disability, what technologies they were using before and after adopting the Mainstream Technology Selection Framework.

Table 6.1. Information from the hypothetical cases and technologies before and after adopting Phase 1 of refining the MTSF

Participants	Gender	Age	Type of disability	Pre-Technology	Post-Technology
Hypothetical_1	Female	64	Spina bifida	Personal alarm box	Alarm system, Ivee sleek
Hypothetical_2	Female	49	Cerebral palsy	Mobile phone	Smart phone with voice recognition feature, holder

Hypothetical_1 is a female, aged 64. She has had spina bifida since birth. She has difficulty controlling her arms and hands. Her disability developed gradually. She attended a special school and currently lives in a care facility. Her most important goal is to be more independent. She wishes to have a technology that would assist her in attracting her carer's attention when she is alone and needs help. She is currently using a personal alarm box. However, the alarm box sometimes falls down when she tries to activate it, making her scared of not being able to get help when it is urgent.

Hypothetical_2 is a female, aged 49. She has had cerebral palsy since birth. She has good gross motor movement in her arms and hands but lacks fine motor coordination. She cannot move her legs at all. She attended a special school and currently lives in a care facility. Her disability is stable. She wants to be more independent. She wishes to have a technology that would allow her to make personal telephone calls without assistance from staff. She currently has to ask staff to make calls for her. In addition, sometimes the phone has broken when she has dropped it.

6.2.2 Procedures of applying MTSF

First, Interview 1 was used to gather data from the hypothetical cases. Interview 1 was given to a disability worker who pre-identified two cases. The disability worker answered the questions of Interview 1 hypothetically based on her experience with the pre-identified cases.

Second, the researcher transferred the gathered data in Interview 1 to the decision tool. As the decision tool consists of the same theme as Interview 1, the data that was gathered under each theme in Interview 1 was transferred to the same node in the decision tool. Each branch in the decision tool ends with a feature of the technology solution. The technology features were detected based on the data feed from Interview 1. Detailed steps of the application of the decision tool with examples are in the next section.

Third, the searching for the technology was performed using a search engine by specifying appropriate key words. The key words represent the technology features that were generated from the decision tool. The first group of words detected the type of the technology with the input preference. When the task and the input requirements were met, the output preferences were checked. Once the technology met the task, input, and output requirements, the features of the technology generated from the environment theme were checked. The technology is adopted as a solution for the case if it satisfied all the features that were generated from the decision tool. Detailed steps of the application of the search tool with examples are in the next section.

Finally, Interview 2 would be used to evaluate the effectiveness of the technology. However, it was not applied in Phase 1, as the purpose of Phase 1 was to ensure the MTSF process and instruments leads to acceptable technology solutions before applying the MTSF on real cases. Interview 1, the decision tool, and the search tool are the MTSF instruments that lead to the technology solution. Thus, ensuring that the right questions were asked in Interview 1, the valuable technology features were produced from the decision tool, and the ability of the search tool to find this technology was enough to achieve the purpose of Phase 1.

6.2.2.1 *Application of the decision tool for Hypothetical_1*

Step 1

Step 1 involved identifying the task and the technology experience.

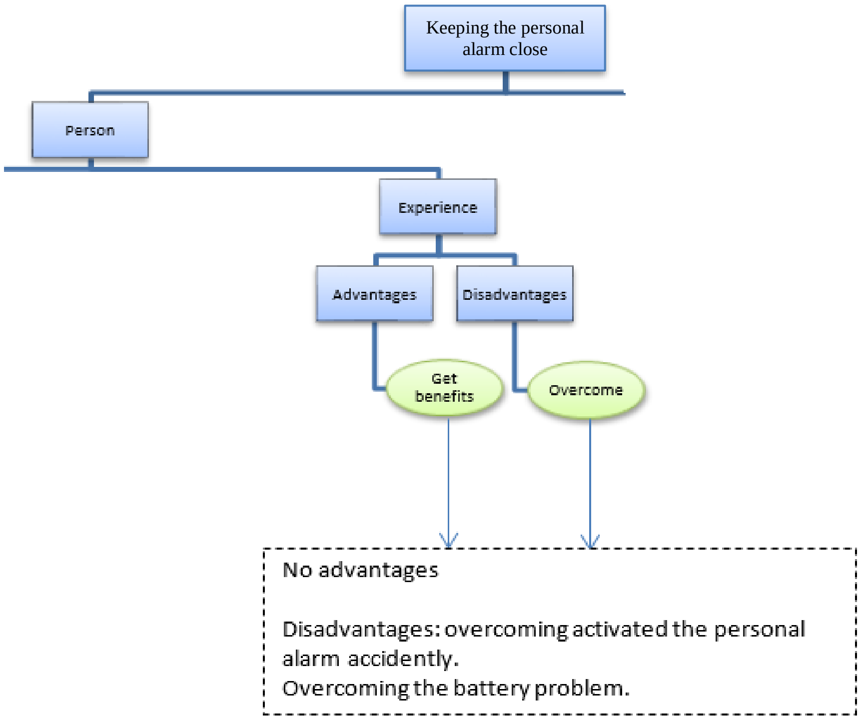

Figure 6.2. Step 1 of applying the decision tool for Hypothetical_1

For Hypothetical_1, the task was being able to activate a personal alarm. In terms of the technology experience Hypothetical_1 was using an alarm box, which was placed next to her bed. The disadvantage of using this alarm box is that she might knock it over accidently and sometimes she can’t reach it. Also, the battery does not always recharge properly. Thus, to overcome the limited technology experience, alarm activation, and battery problem, the decision was to find a simple and easy to use technology that has longer battery life or an extra battery and another way to activate the alarm.

Step 2

Step 2 involved identifying the person's abilities. The person's abilities had been used to detect the appropriate input and output channels for the cases.

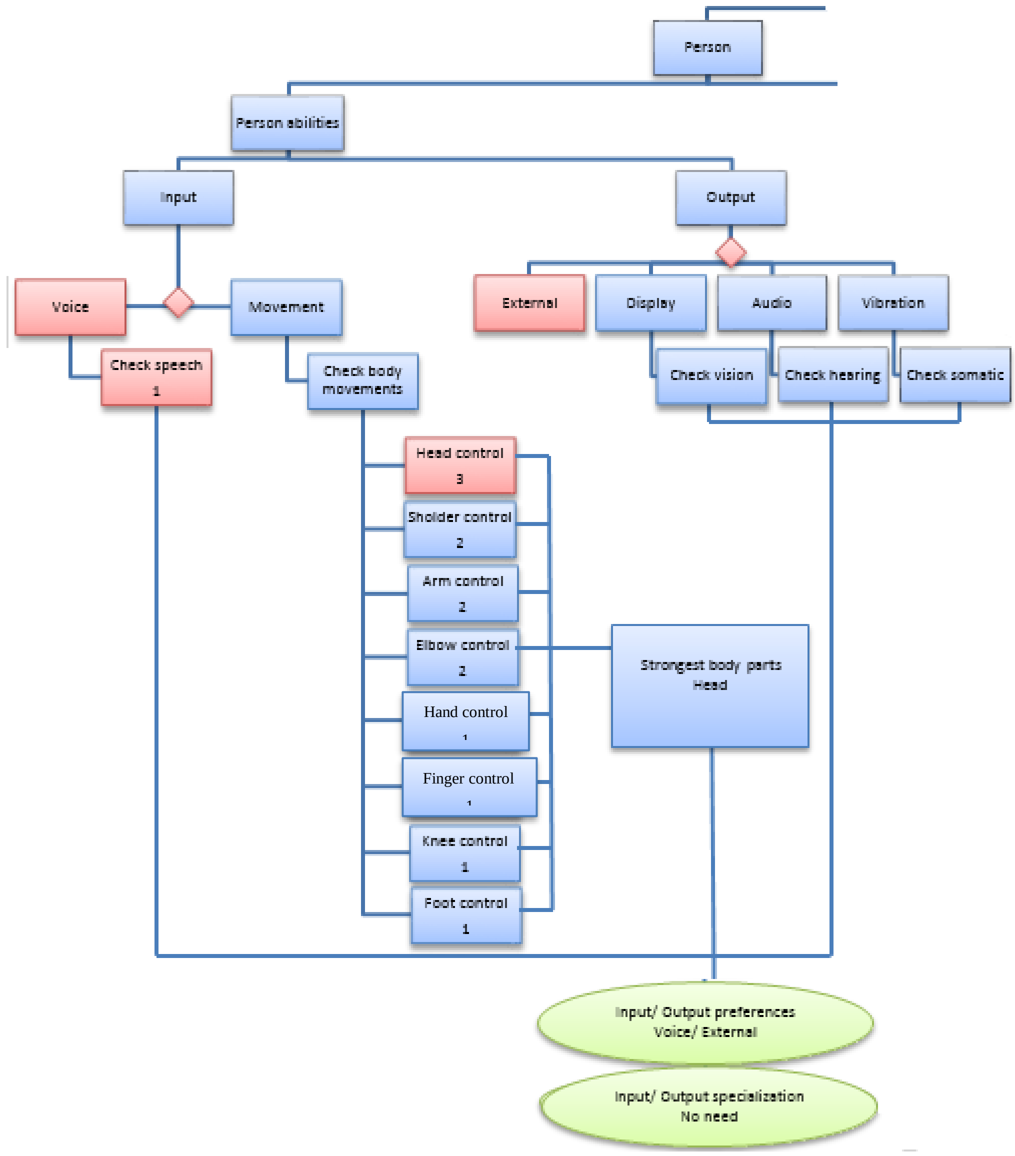

Figure 6.3. Step 2 of applying the decision tool for Hypothetical_1

After assessing the abilities of Hypothetical_1, according to the assessment scale of 5 points from 0 for no ability at all to 5 for excellent ability, it is obvious that the strongest body part that could be used to interact with the technology was the head (highlighted in red in Figure **6.3**). However, because she preferred to activate the technology by voice (highlighted in red in Figure **6.3**), her preferences were given the priority. Thus, the decision is to consider the voice as an input method. When Hypothetical_1 needs help she wants to notify someone - the output in this case is external. To achieve the maximum accessibility, any input/output specialization needs due to the disability should be considered. In the case of Hypothetical_1 no specialization is needed.

Step 3

Step 3 involved identifying the environmental factors which affect the technology features.

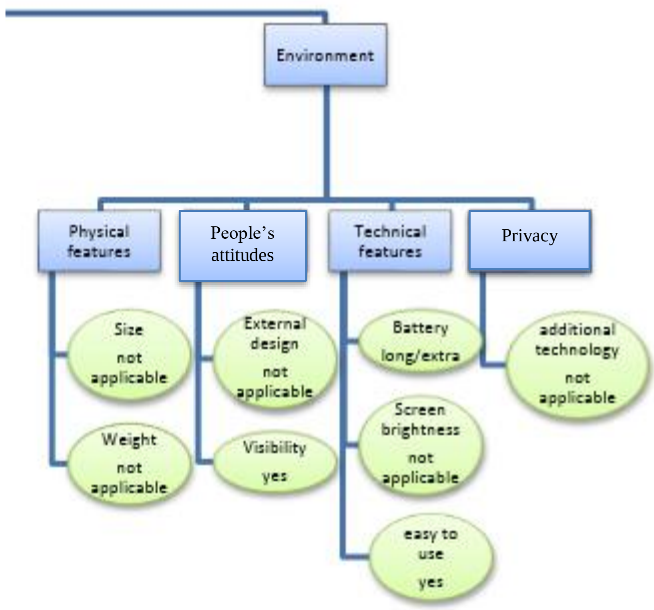

Figure 6.4. Step 3 of applying the decision tool for Hypothetical_1

Hypothetical_1 intends to use the technology in a normal household environment. The environmental factors affect the technology physical features, technical features, and the requirement of any additional hardware or software. In the case of Hypothetical_1 the physical features including the technology size, weight, and external design are not important because the personal alarm will be placed next to her bed. The technical features should cover the need of Hypothetical_1 by having an easy to use technology with long battery. The privacy is not an issue in this case so no additional technology is required.

Consequently, the requirements for Hypothetical_1 was a personal alarm with the following features:

- Simple and easy to use
- Accepts voice input
- Sends an alarm to an external remote device
- Long life battery

The next section explains the searching process for the above technology features using the search tool.

6.2.2.2 *Application of the search tool for Hypothetical_1*

Step 1

Step 1 involved identifying the type of the technology to start with.

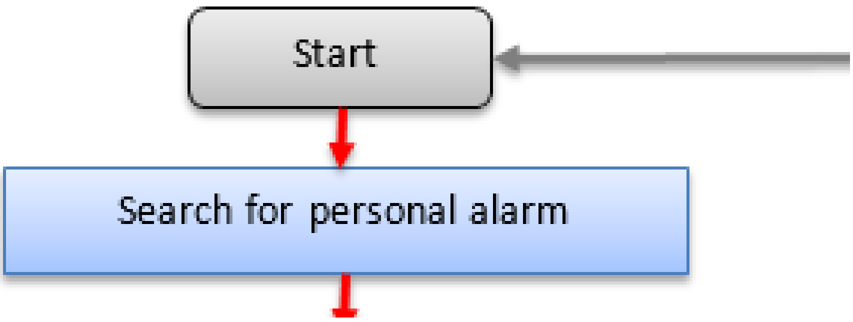

Figure 6.5. Step 1 of applying the search tool for Hypothetical_1

The task was translated to the type of the technology being used as search terms. The task of Hypothetical_1 was being able to activate a personal alarm. Thus, the translation was as follows:

(Task = type of the technology)

(Activation of a personal alarm = personal alarm)

Step 2

Step 2 involved checking the availability of the preference input method.

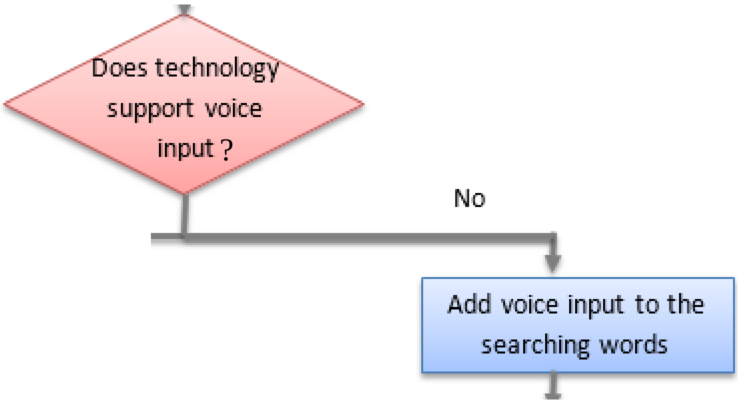

Figure 6.6. Step 2 of applying search tool for Hypothetical_1

Hypothetical_1 preferred a voice as an input method. Thus, the founded technology should have this input form.

Step 3

Step 3 involved checking if the output accommodates the person's weaknesses.

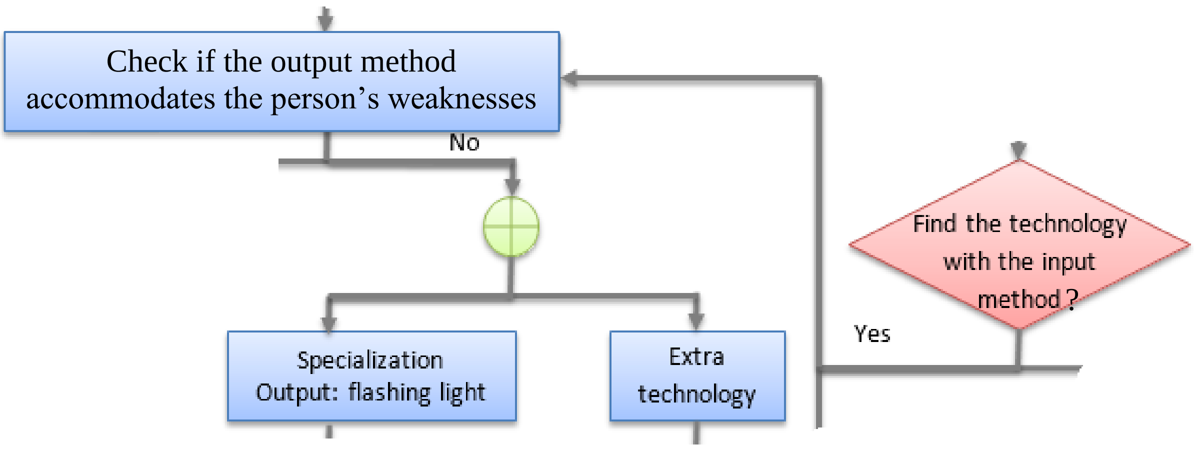

Figure 6.7. Step 3 of applying the search tool for Hypothetical_1

Hypothetical_1 has poor vision and hearing. Although the output in this case is external to notifying someone that Hypothetical_1 needs assistance, it is still important to notify

Hypothetical_1 that her asking for assistance was successfully executed by using a flashing light on the screen of the alarm to accommodate her weak vision and hearing.

Step 4

Step 4 involved checking the candidate technology against the environment features.

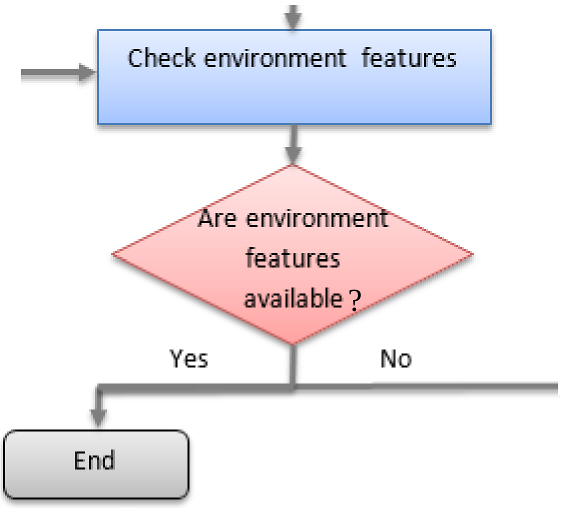

Figure 6.8. Step 4 of applying search tool for Hypothetical_1

Hypothetical_1 wanted to use the personal alarm clock in her room. She usually put the personal alarm on the table next to her bed. Thus, Hypothetical_1 will not travel with the technology around the house or outdoors so the environment features were given less consideration in this case.

The recommended technology solution for Hypothetical_1 was a smart alarm system called Ivee sleek. Ivee sleek meet the technology requirement features which were generated from the decision tool. Ivee sleek:

- Is easy to use as it is accept voice commands.
- Can receive a voice input
- Can notify an external device to ask for assistance

Ivee sleek has a long life battery. It displays a message when the battery needs to charge.

6.2.2.3 *Application of the decision tool for Hypothetical_2*

Step 1

Step 1 involved identifying the task and the technology experience.

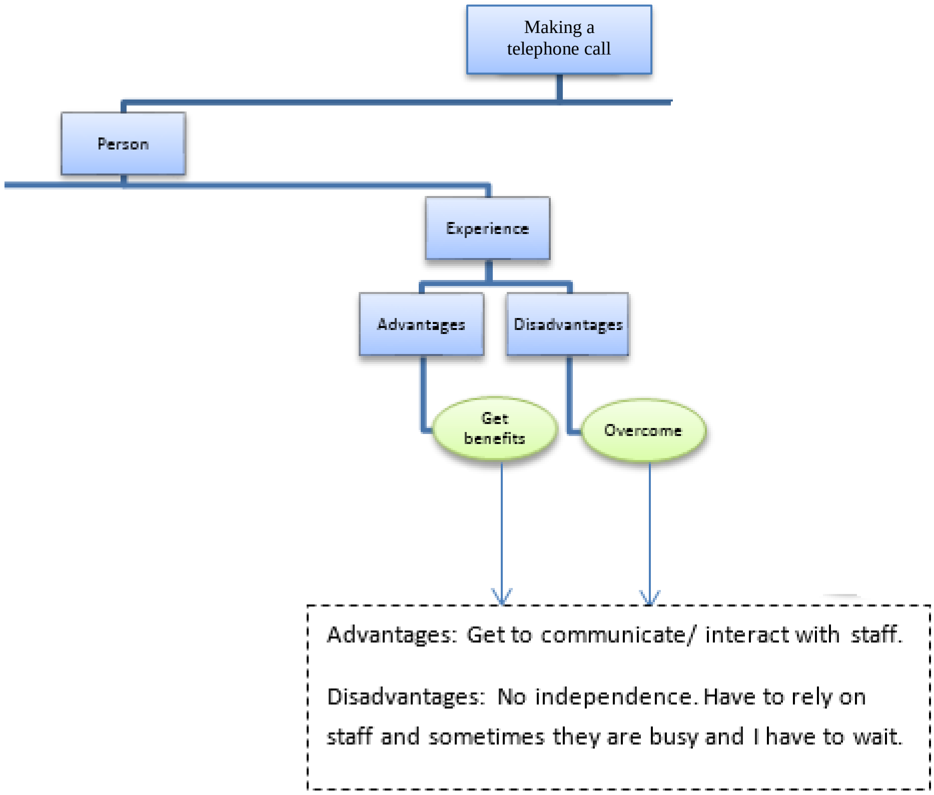

Figure 6.9. Step 1 of applying the decision tool for Hypothetical_2

For Hypothetical_2 the task was making a telephone call without assistance. Hypothetical_2 was asking staff to help her use a cordless phone or mobile phone to make calls. However, the phone sometimes got broken because she accidently dropped it. Thus, to overcome the problem of being dependent on others and waiting, the decision was to provide a technology that enables her to make calls without assistance which gives her more independence.

Step 2

Step 2 involved identifying the person's abilities. The person's abilities had been used to detect the appropriate input and output channels for the cases.

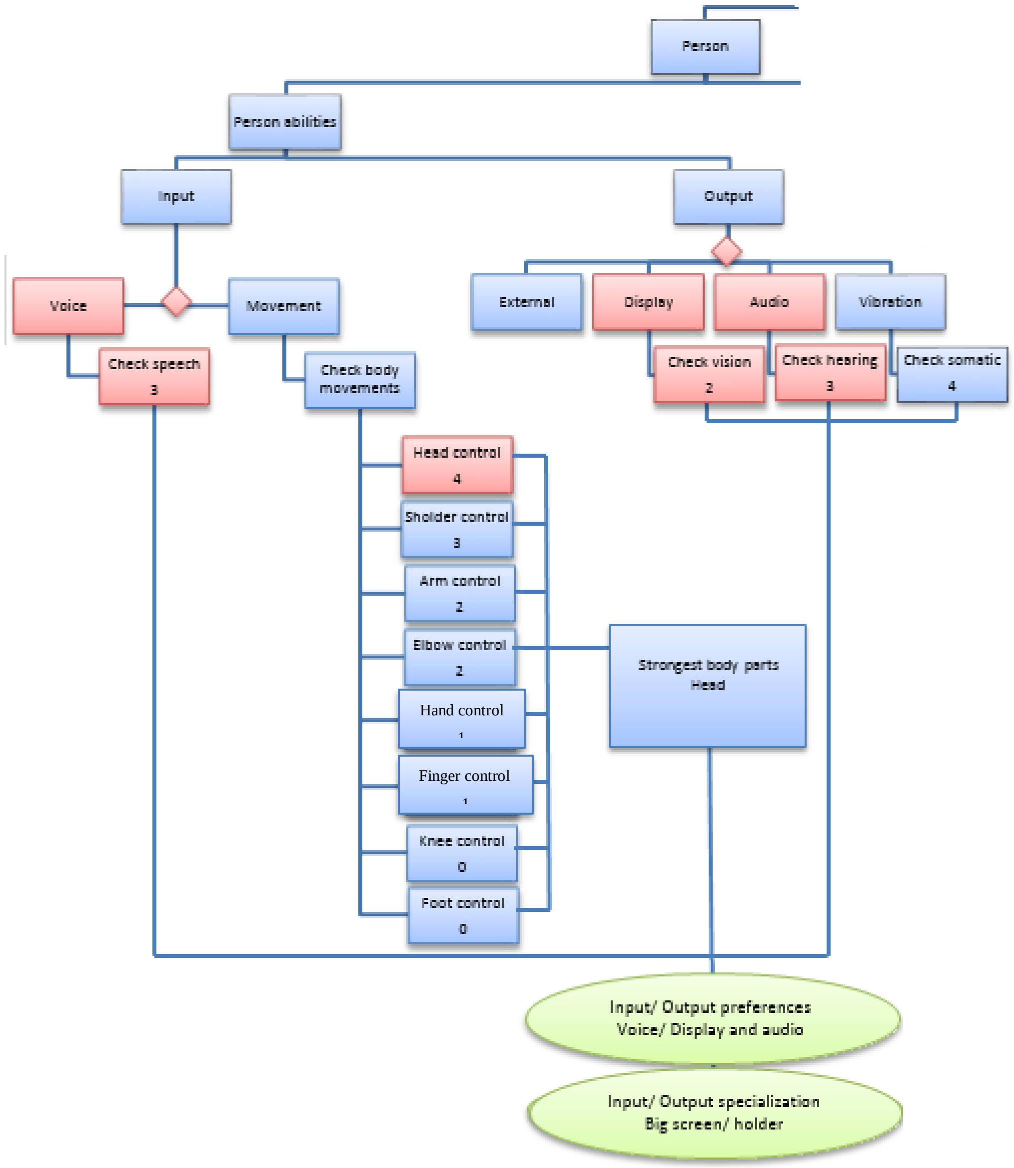

Figure 6.10. Step 2 of applying the decision tool for Hypothetical_2

The abilities assessment of Hypothetical_2 showed that she has a good speech ability and head movement. However, the priority was given to her preference: using voice as an input method. Thus, the decision was to consider the voice as an input option. In terms of the output, it took two forms: display and audio so the decision tool checked Hypothetical_2 abilities against these two forms. She has a good hearing ability but only fair vision, so an output specialization should be considered by providing a technology with large text on screens. In addition, a holder should be provided to overcome the problem of dropping the phone.

Step 3

Step 3 involved identifying the environmental factors that affect the technology features.

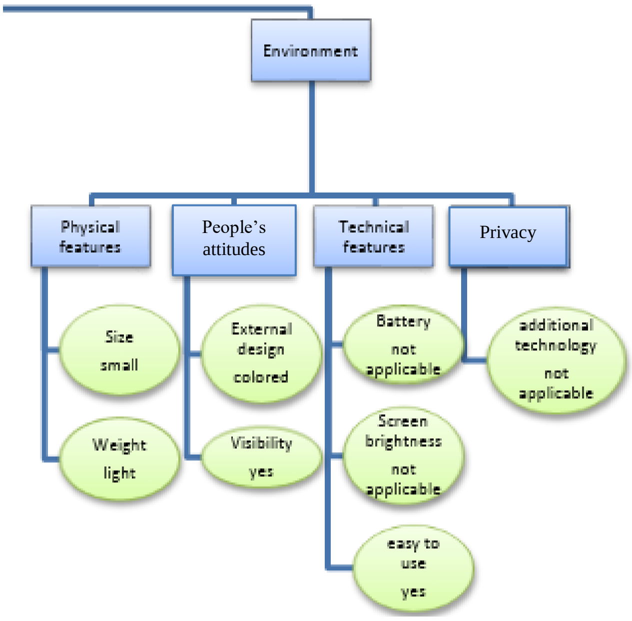

Figure 6.11. Step 3 of applying the decision tool for Hypothetical_2

Hypothetical_2 intended to use the technology in a normal household environment. However, because she wanted to take the technology with her everywhere around the house, the size and the weight were important. Thus, the technology should be small and light. Even though Hypothetical_2 intended to use the technology indoors, she was concerned about the external design of the technology. A coloured technology as she had requested was considered. In terms of the technical features, indoor use would make things like the battery life and the brightness of the screen less important. Again, the privacy was not considered an important issue, as she would use the technology indoor. No additional technology was required.

Consequently, the technology solution for Hypothetical_2 was a smart mobile phone with the following features:

- Accept voice input
- Large text and big screen
- Holder for the mobile phone on the wheelchair
- Small and light
- Beautiful external design (coloured)

The next section explains the searching process for the above technology features using the search tool.

6.2.2.4 *Application of the search tool for Hypothetical_2*

Step 1

Step 1 involved identifying the initial type of the technology.

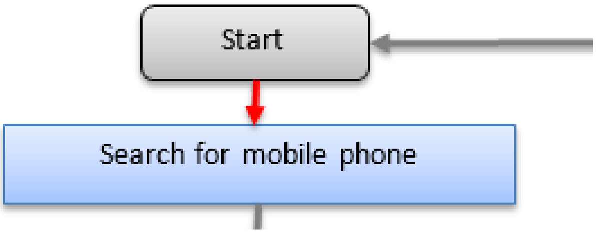

Figure 6.12. Step 1 of applying the search tool for Hypothetical_2

The task was translated to the type of the technology for use as search terms. The task of Hypothetical_2 was being able to make a call. Thus, the translation was as follows:

(Task = type of the technology)

(Making a call = mobile phone)

Step 2

Step 2 involved checking the availability of the preferred input method.

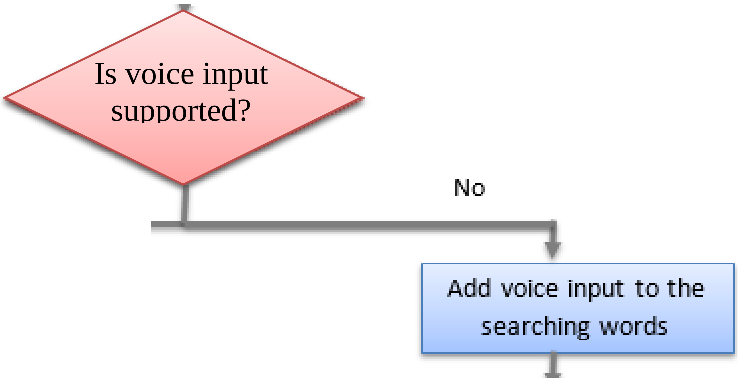

Figure 6.13. Step 2 of applying the search tool for Hypothetical_2

Hypothetical_2 preferred voice as an input method. Thus, the candidate technology should have this input form.

Step 3

Step 3 involved checking if the output accommodated the person's weaknesses.

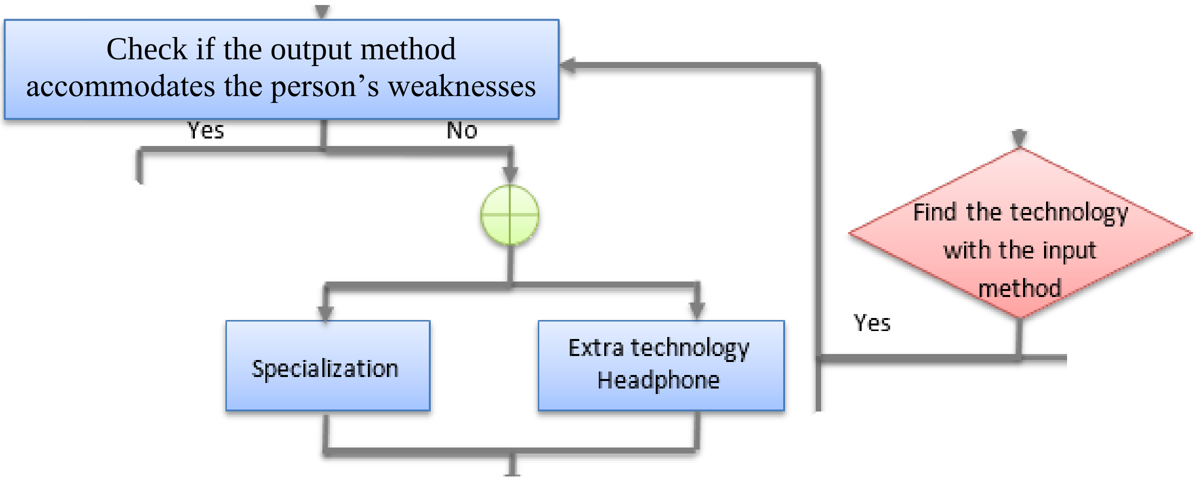

Figure 6.14. Step 3 of applying the search tool for Hypothetical_2

Hypothetical_2 had a hearing difficulty, so the candidate technology had to be compatible with a headphone. This allowed her to hear the caller and protected her privacy as well.

Step 4

Step 4 involved checking the candidate technology against the environment features.

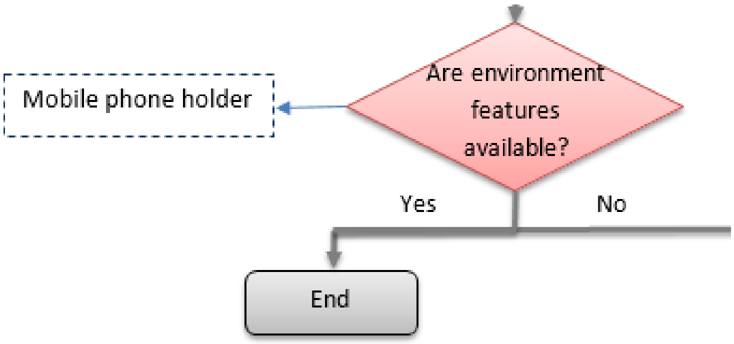

Figure 6.15. Step 4 of applying the search tool for Hypothetical_2

Hypothetical_2 wanted to use the technology around the house. Providing a holder for the mobile phone to mount on her wheelchair overcame the weaknesses in her arms and hands.

The recommended technology solution for Hypothetical_1 was a smart mobile phone (such as the iPhone). The iPhone meets the technology requirement features which were generated from the decision tool. The iPhone mobile phone:

- Accepts voice input (has the Siri feature which has voice activated calling)
- Has a big screen and accessibility features such as text size.
- Has a beautiful external design.

With the holder, the iPhone's size and weight problem will be solved.

The following section presents the findings of analysing the responses of the disability expert to the questions of Interview 1.

6.3 Findings analysis

The purpose of the analysis in this phase was to ensure that the important and necessary information was collected to conduct a successful matching between the person with the disability and the appropriate mainstream technology. The quality of the question's structure and the importance of the question were determined by analysing the responses. The effectiveness of the responses was determined based on the factors that play a crucial rule in the matching process (see Chapter 4 for the factors). The responses to the questions of

Interview 1 were analysed and coded in Nvivo 10 software. The data was coded to two nodes: effective responses and ineffective responses. Explanations with quotes from Interview 1 are presented in the following sections.

6.3.1 Effective responses

If the response is effective and provides the targeted and important piece of information for conducting a good match that means the question is important and well-structured, requiring no action. Next, I will go through some effective responses from Interview 1.

6.3.1.1 *The type of the task*

The task is the backbone of the Interview 1 questions. According to the MTSF the task is the first piece of information that needs to be determined and clearly specified because the rest of the Interview 1 questions depend on it. After determining the task, more information is gathered about the current situation: the advantages and disadvantages of the current way they complete the task.

When the participants were asked about their tasks that required technology to accomplish, they mentioned a list of tasks. However, some of the tasks cannot be suitably accomplished using mainstream technology. Consequently, all tasks that did not satisfy the previous condition such as:

> *"Help me eat more independently" (Hypothetical_1)*
>
> *"Give me my medicine" (Hypothetical_1)*
>
> *"Mobility transfers (into bed and wheelchair)" (Hypothetical_2)*

were excluded. These kinds of tasks require mobility technologies that are beyond the scope of this research.

On the other hand, tasks such as:

> *"Keep my personal alarm close by" (Hypothetical_1)*
>
> *"Change channel on TV or play CD for me without needing assistance from staff" (Hypothetical_2)*
>
> *"Requiring staff to dial a number for me when I need to make a telephone call" (Hypothetical_2)*

could be achieved using mainstream technology. To overcome this misunderstanding the question needed to be made clearer by explaining to the participants what types of tasks could be achieved using the mainstream technologies. However, as some of the participants may have no experience in using technologies which make it difficult for them to distinguish between the previous two types of tasks. In addition, the aim of Interview 1 was to gather as much information as possible from the participants. Limiting the answers in specific types of tasks could prevent them from disclosing all information they think about. Consequently, the question was left open, enabling the technology specialist to choose the task that could be solved given that the solutions should be from the mainstream technologies range.

6.3.1.2 *Analysis of the current situation*

Analysing the current situation for the participants in terms of accomplishing the task gave the researcher important information that assists knowing if the participants tried to use technologies before and the advantages and the difficulties that they faced. The advantages of the current situation could be used to guide the selection of the solution; the disadvantages needed to be overcome to offer a better solution.

Hypothetical_1 wanted to have a personal alarm that overcame the disadvantages of the current one that is being used

> *“Keep my personal alarm box on my bed or on the table, however If I knock it over accidently, I cannot activate it” (Hypothetical_1)*

Her response gave information that she already used a personal alarm; however, a difficulty prevented her from using it properly. Gathering this information in Interview 1 helped to overcome Hypothetical_1’s difficulty of being unable to activate her personal alarm by gaining the benefit of her abilities. The problem was that she sometimes accidently knocked the alarm. She has a weakness in her arms and hands which leads to uncontrolled movements. In this case, being able to rely on the speech ability can be a solution for Hypothetical_1. A personal alarm such as the Ivee sleek alarm can be activated by voice and can also be connected to a smart device to draw staff attention when Hypothetical_1 needs help.

Hypothetical_2 mentioned a difficulty making calls because she has cerebral palsy which causes a lack of fine motor skills.

"Requiring staff to dial a number for me when I need to make a telephone call" (Hypothetical_2)

She responded to the question about the disadvantages of the current way of making calls by saying

"No independence and have to rely on staff and sometimes they are busy and I have to wait" (Hypothetical_2)

"Phones breaking if I accidently drop them" (Hypothetical_2)

She currently asks the staff to help her using the cordless phone and mobile phone. Hypothetical_2 wants to be independent and be able to make phone calls without help so she will not need to wait for staff assistants. Considering the ability of Hypothetical_2, a smart phone with voice features or pre-programed contact list icons can be a way to be more independent.

6.3.1.3 *Preferences of technology features*

Another question in Interview 1 gathered valuable responses from the participants. The question was about the technology features such as size, weight, and the preferred interaction method. The responses to this question were similar between Hypothetical_1 and Hypothetical_2.

Because it is a personal alarm which will be used in Hypothetical_1's room, the most important feature for her was the interaction method. She wanted a technology that could be activated using voice or touch.

"I don't mind if the technology is visible and I preferred the Interaction method: voice control or touch control" (Hypothetical_1)

Hypothetical_1 can be independent with the Ivee sleek alarm, however she can also feel safe by being able to ask for help when she needs.

Hypothetical_2 gave more features for the technology. It is important for her to have a technology that satisfies her needs in terms of travelling with this technology inside the care facility or outside

"I want the technology to be small, light, easy to use, coloured and Interaction method: voice control or touch control" (Hypothetical_2)

A smart phone with a voice or touch screen mounted on Hypothetical_2's wheelchair can overcome the lack of fine motor skills.

6.3.2 Ineffective responses

In contrast to the effective responses, if the response is ineffective or does not offer any addition information for technology selection, an action needs to be taken to improve Interview 1. Possible actions include deleting the question, adding a new question, or restructuring the question to get more useful responses.

6.3.2.1 *The broad experience*

The level of complexity of the technology solutions can be predicted using the experience of the participants regarding the use of technologies. Gathering information about whether the participants used any technology is important to detect the level of experience the participants have. The responses of Hypothetical_1 and Hypothetical_2, when they were asked if they ever use any technology to help them overcome disability limitations, were:

> *"Use the hoist to get in and out of my (wheelchair, bed)" (Hypothetical_1)*
>
> *"Hoist and Phones" (Hypothetical_2)*

The responses indicated that the question was too broad to include many facilitators such as mobility aids. Thus, we needed to restructure the question to specifically ask about the technology that the participants already used to accomplish the task, which they identified at the beginning of Interview 1.

6.3.2.2 *The level of education*

The level of the education is not effective information when it comes to use of mainstream technologies these days, as many people with low levels of education can use them in an effective way.

> *"What level of education do you achieve? Attended special school" (Hypothetical_1), (Hypothetical_2)*

Thus, the question about the education level had been removed from Interview 1.

6.3.2.3 *Ignoring the priorities*

It is crucial to consider the participant's priorities in order to make them feel comfortable when interacting with the technology. In addition, they feel involved in the technology selection process which increases the likelihood of using the technology. Interview 1 has a section that separately assesses each ability of the person on a scale of 1 to 5. The purpose was to find the strongest body part that can be used as an interaction method with the technology. However, in some cases the same score had been given to more than one ability. This led to a new question being added asking the participants to order their priorities regarding the abilities that have the same score. So the ability that they prefer to use more to interact with the technology will get the highest priority.

6.3.2.4 *Stability of the disability*

Gathering information about the stability of the disability is ineffective because the assessment of the participants considers the current situation of the disability. Any change in the current situation of the disability whether for better or worse, requires a new assessment. Moreover, a new assessment needs to consider other changes as well which are affected directly by changes in the disability situation such as changes in environment and technology preferences.

6.3.2.5 *External design and environment*

The external design of the technology includes being visible or inconspicuous, size, weight, and colour. For Hypothetical_1 the external design features were not important, as the technology she needed was a personal alarm which was fixed on the bed side table. Whereas the situation was different for Hypothetical_2. Hypothetical_2 needed a mobile phone so she can make calls without asking for assistance from the staff. To achieve that, the mobile phone should be small and light to mount on her wheelchair. Furthermore, because she will use the mobile phone front of others she mentioned that she is interested in a good looking mobile phone including the colour.

The external design is mostly affected by where the person decides to use the technology. Thus, the questions related to the external design of the technology were moved from the personal information section in Interview 1 to the environment section.

6.4 Discussion

This section discusses the changes to the Mainstream Technology Selection Framework after analysing the two hypothetical cases responses. Table **6.2** presents the changes that had been made in Interview 1 along with the reason for each one. Changes are discussed in light of the literature, theoretical framework, and practical implications of the Mainstream Technology Selection Framework.

Table 6.2. The changes to MTSF to develop $MTSF_1$ and the reasons for these changes

	Changes		
	MTSF Interview 1 questions	**$MTSF_1$ Interview 1 questions**	**Reasons**
Ch1	Did you ever use any technology to help you overcome disability limitations?	Did you ever use any technology to help you do the task?	Makes the question more specific to the identified task
Ch2	What level of education do you achieve?	*Deleted*	As the recommended technology is a mainstream technology no knowledge of education level is required
Ch3	*No question asked*	Do you prefer a specific method(s) to interact with the technology? Can you order them from higher preference to lower one?	To order the priority interaction methods in case more than one interaction capability is available.
Ch4	Is the disability stable or degenerative?	*Deleted*	The mainstream technology solution is recommended to the people with disabilities given their current assessment including their current abilities. Thus, even if the disability is degenerative that means the current assessment is not valid and a new assessment needs to be conducted. In each assessment all changes should be considered (such as the task, environment, and technology preferences) not just the change in the disability.
Ch5	Do you have any experience regarding technology use?	*Deleted*	Duplicated question as it is already covered by questions: “Did you ever use any technology to help you do the task?” and “Have you had any problems with technology that supported you in the past?”

	Changes		
	MTSF Interview 1 questions	**MTSF$_1$ Interview 1 questions**	**Reasons**
Ch6	Do you prefer the technology to be visible or inconspicuous? Do you have any special requirements to regards of? ● Technology size: ● Technology weight: ● Technology's features: ● Other:	*Moved from the personal information section to the environment section*	Because the external design of the technology is directly related to the environment where the participant will use technology.
Ch7	What is the issue that is highlighted as the most priority for you? ● Completing the task perfectly ● Completing the task in shortest possible time ● Completing the task with less effort ● Other	*Deleted*	Given the main goal of Interview 1 which is collecting data to choose the most appropriate mainstream technology for the participant this question is unnecessary. The other questions and the solution should combine these points. The goal and then the analysis of the current situation should give an idea of the exact needs of the participant as regards considering the solution as a successful one. The biggest concern with the current method could be the perfection, time or effort. The solution should satisfy at least the biggest concern, or in the perfect situation, the combination of the three.
Ch8	Relative-advantage or (cost-benefit) ● Do you think you will get benefits from using technology? ● What kind of benefits do you think you will get? ● What kind of problems do you think you will face?	*Moved to Interview 2 after using the technology*	Measuring the relative-advantages should occur after using the technology as the participant has a good idea about the advantages of the technology when taking the cost into consideration.
Ch9	*No question asked*	How do you want to interact with technology (sitting, on the go)?	Important to detect the position for perfect interaction
Ch10	*No question asked*	How long/often do you expect to use technology?	Important to ensure the most comfortable interaction time
Ch11	*Resources questions*	*Deleted*	Refined the scope of the research. As the mainstream technologies are not subject to service delivery policies because they are mostly affordable, the resources questions are unnecessary.

The next sections will discuss the major findings and relationships in Table **6.2**.

6.4.1 The role of the experience

The level of complexity of the technology solutions can be predicted using the experience of the participants regarding the use of technologies. Gathering information about the participants' use of technology is important for detecting the level of experience the participants have. However, the experience of assistive technology use of the person with disability could be too broad to specifically mention something like mobility aids and bath tools. The type of the experience needed to be collected is the experience related to electronic technology. The role of the person's experience in processes of technology selection is only rarely mentioned in the literature, such as in Scherer and Glueckauf (2005) when they considered the past experience of using technologies as one of the factors which shape the person's expectations and reactions towards a new technology. They found that the participants who had a positive experience with their previous technologies showed a better performance with the new technologies. From the researcher point of view, the lack of indication of the experience in the literature is due to the majority of the literature dealing with assistive technology specifically designed for people with disability. Thus, it is obvious that experience is not expected in this case. However, in the case of mainstream technology, which is the scope of this research, the experience is something expected. Whether the people had the disabilities in later stage of their life or from birth, it is expected that they used a mainstream technology or even tried to use it. Consequently, gathering information about these experiences and how they went plays a crucial role in the selection process. The theoretical framework (activity theory) of this research does not mention the experience. However, the experience can be added to the subject concept. The subject concept is redefined to be the person with disability in the disability context. In terms of the implication of the role of the experience changes are made to the Mainstream Technology Selection Framework, by making the question about the experience more specific to the electronic technology (Table **6.2**, Row 'Ch1'). Modifying the experience question to be specific to the technology that had been used to do the task detected at the beginning of Interview 1, guarantees that the experience is related to the electronic technology. This change helps detect the level of experience that guides the detecting of the level of the complexity of the recommended technology.

6.4.2 Priority consideration

The priorities include the interaction method priority, in case the person with the disability can interact with the technology via a number of methods with the same level of ability. The importance of considering the priorities of the person is reported extensively in the literature such as Seymour (2005) and Scherer et al. (2007). They stated the importance of considering the change in priorities of the person over time and across different environments. However, because this research focuses on the assessment of the current situation of the person with the disability, the priorities are considered in terms of the available interaction methods but not on the time of the assessment. The changes in priorities over time or change of environment are not considered any change in the current situation of the person with the disability. This lack of consideration requires new assessment. The theoretical framework (activity theory) of this research does not mention the person's priorities, however, they have been added under the subject concept after redefining the subject concept to be the person with disability. In terms of the implications of the consideration of the person's priorities, a question has been added to the Mainstream Technology Selection Framework (Table **6.2**, Row 'Ch3'). This question was added after the assessment of the person's abilities to order the person's abilities in terms of the interaction methods. Consideration of the person's priorities increases the likelihood of using the recommended technology, as the person feels involvement in the technology selection process.

6.4.3 Keep abreast of the current assessment

The initial assessment of the person with disability was based on the current situation's data collected in Interview 1. As the factors that affect the technology selection process overlap, any change in the current situation of the person affects the whole assessment. In the literature, the importance of considering the changes of the person's situation is reported as an effective way to ensure that the person will continue using the technology (Priest & May 2001; De Jonge & Rodger 2006). As this research is concerned with recommending a mainstream technology for the person with disability, the focus is on the current situation of the person with less consideration being given to the changes. This does not mean that considering the changes is not important in the case of the mainstream technology; it is just that the cost of mainstream technology is less than that of assistive technology. So any change in the disability for better or worse requires consideration of all other factors such the task, environment, and technology preferences. Assistive technology is the focus of the literature. In the researcher's view, the high cost of assistive technology is due to being specifically designed for people with disability. They want to get the most benefit from using it and thus use it for the longest time possible, despite any changes in their situation. Considering situational changes is not an important issue in the case of the mainstream technology as different mainstream technologies can be chosen for a changed situation. It is not considered in the theoretical framework (activity theory) of this research. In terms of the Mainstream Technology Selection Framework the question that considers the changes in the abilities of the person was deleted (Table **6.2**, Row 'Ch4').

6.4.4 The relationship between environment and external design

Gathering enough information about where the person intends to use the technology is an important step in getting a clear overview of the technology required to accommodate that environment. Literature such as (Goette 1998; Priest & May 2001; Copley & Ziviani 2005; Scherer & Glueckauf 2005; De Jonge & Rodger 2006) gave the environment issue special consideration. The Mainstream Technology Selection Framework has a high level question regarding the environment: 'where do you intend to use the technology?' However, the analysis of the hypothetical cases responses showed that there is a relationship between where the person wants to use the technology and the external design features of the technology. This relationship has been mentioned in the literature in the context of using the technology in public places. When the people intend to use the technology in public places, they usually concerned more about their technologies design features such as size, weight, and colour. In addition, they are concerned about features such as privacy, screen brightness, battery life, and internet connection. As a result of this relationship, the questions related to the technology features preferences were moved to the environment section in Interview 1 (Table **6.2**, Row 'Ch6'). In terms of the theoretical framework (activity theory), the environment is considered under the community concept and a relationship between the environment and the technology concepts are drawn.

6.4.5 Successful technology solution

The main goal of Interview 1 is to find the most appropriate mainstream technology solutions for participants. This requires implicitly taking into account completing the task with an acceptable level of correctness and having invested reasonable amounts of time and effort. Otherwise the solution will not be an appropriate one. Carefully detecting the goals of the participants during the beginning of the Interview 1 is one of the important steps in assessment the participants need. In addition, accurate goal detecting leads to the best task-technology fit. The second step to ensure the best task-technology fit is analysis of the current situation for doing that task. That should give an idea of the exact difficulties faced by the participants such as effort, pain, time, or the quality of the result. Paying attention to these considerations offer a major part of the successful solution. A successful solution for the person is one that overcomes the biggest concern with the current method, which could be correctness, time, or effort. The solution should satisfy at least the biggest concern or in the ideal situation, the combination of the three. Goette (1998) listed the factors that affect the successfulness of the technology solutions. He stated the task-technology fit as a major one. When the technology does not work well enough to achieve the stated goal the users will not be happy with the user experience. He gave a (large vocabulary) voice recognition system for drafting as an example that leads to user frustratration. The frustration was due to the drafting technology having overly large vocabulary lists to choose from. For drafting the user needs just a basic vocabulary list, so the (large vocabulary) voice recognition technology does not fit well with the drafting task. The task-technology fit is not considered in the theoretical framework (activity theory) of this research. However, it was added to the activity theory as a relationship between the task and the technology concepts, including overcoming time, effort, and perfection issues. The Mainstream Technology Selection Framework considered the two steps to ensure a successful technology solution, which included carefully detecting the goal at the beginning of Interview 1 and analysing the current ability of the participants in detecting the most important difficulties. As a result, the question about the most highlighted priorities in completing the task was deleted (Table **6.2**, Row ‘Ch7’).

6.5 Implications

The findings analysis and discussion improve the theoretical framework (activity theory) to be applicable in the disability context. The improvements are a reflection of the responses of the participants in the hypothetical cases phase to increase the quality of the technology solutions. In addition, other improvements are a reflection of some emergent relationships between concepts. The improvements include adding new factors and relationships between concepts to the theoretical frameworks. Experience and priorities are examples of new factors which were added. The relationship between environment and technology features and the relationship between task and technology emerged to explain the connections between the existing and new factors. $MTSF_1$ presents all the refinements in this chapter after analysing the hypothetical cases responses.

$MTSF_1$ (Amended version after Phase 1)

Interview (1): Data collection (step 1)

Name ______________________________ Code ______________________________

Age ______________________________ Contact details ______________________

Date of interview (1) ___________________

Type of disability ____

Brief description ____

____

____

1. Tasks (activities)

Can you suggest at least THREE activities for which you wish you had technology?

I wish there is a technology that helps me do:

____

____

____

____

Ignore the following question in case the participant answered question (1)

What are the kinds of activities that family members or carers do for you?

____

____

Analysis of current situation:

How do you currently accomplish the task?

Choose one task from question (1) or (2) to complete the rest of the interview.

____

____

____

What are the advantages of the currently used method?

____

____

____

What are the disadvantages of the currently used method?

____

____

____

Ask the following question in case the participant mentioned non-technological method in question (1)

Did you ever use any technology to help you do the task?

____

____

Have you had any problems with technology that supported you in the past?

____

____

2. Personal information

Abilities

How do you rate and describe your ability in regards to the following interaction capabilities?

*Interaction capabilities scale: 0(None), 1(Poor), 2(Fair), 3(Good), 4(very Good), 5(excellent).

Capabilities	Rate	Description
Vision	……..	………………………….………
Hearing	……..	…………………………………
Somatic (the ability to sense touch)	……..	…………………………………
Audio (speech)	……..	…………………………………
Head control	……..	…………………………………
Shoulder control	……..	…………………………………
Arm control	……..	…………………………………
Elbow control	……..	…………………………………
Hand control	……..	…………………………………
Finger control	……..	…………………………………
Knee control	……..	…………………………………
Foot control	……..	…………………………………

Do you prefer specific methods to interact with the technology?

____

____

____

3. Environment

Where do you intend to use the technology? (Indoor, outdoor)

____

____

How do you want to interact with technology (sitting, on the go)?

____

____

____

How long/often do you expected to use technology?

____

____

____

How do the attitudes of people around you affect the use of the technology?

____

____

____

Do you prefer the technology to be visible or inconspicuous?

____

Do you have any special requirements in regards of?

Technology size ____

Technology weight ____

Technology's features ____

Other ____

____

Would you like to add anything?

____

____

____

Interview (2): Evaluation (step 4)

Name ________________________________ Code ________________________________

Technology ____

Date of evaluation _______________________________________

How long had the technology ______________________________

Number of times using technology _________________________

1. The goal (needs)

What was your goal?

____

Did the technology help you achieve your goal?

____

____

____

How effective your technology is (the degree to which the technology meets your needs)?

____

____

____

How does the technology overcome the previous difficulties?

____

____

____

Do you still need help from family members or carers to do any part of the task?

How do you compare the previous method of doing the task and using the technology to do the same task?

Were there other things that you used the technology for?

2. The technology

What was the technology that you used?

What task were you doing using the technology?

What are the advantages of the technology?

How easy was it to use your technology?

How comfortable was your technology (physically and emotionally)?

Were there any difficulties in using the technology?

How does the use of the technology meet your expectations?

How satisfied are you with:

- Physical features (e.g. size, weight)

- External design (e.g. colour, visibility)

- Technical features (e.g. battery, screen brightness)

- Privacy (e.g. sound)

3. The environment

Did you use the technology in the environment you intended? If not why?

How did the technology overcome the environmental barriers (light, sound)?

How do the opinions of people around you affect your continued use of the technology?

Would you continue use the technology in the future? Why?

6.6 Conclusion

In this chapter, findings from analysing the hypothetical cases were presented. Analysing the hypothetical cases started by coding the responses of the participants to Interview 1 by using Nvivo software. The findings were divided into two main themes based on the value of the collected data. The first theme contains the effective responses. The purpose of the first theme is detecting important pieces of information for conducting good technology selection. The second theme is ineffective responses. The purpose of the second theme is to detect the questions that need to be removed or restructured to get more useful information. These main themes, subthemes, and the relationships between them represented the interesting findings that were used to refine the MTSF. $MTSF_1$ presents all refinements which emerged in this chapter. The next chapter presents the findings and discussion of applying $MTSF_1$ by using six main cases.

Chapter 7

Refinement Phase 2: from $MTSF_1$ to $MTSF_2$ through Main Cases

7.1 Introduction

This chapter explains the refinement of the $MTSF_1$. First, it states the purpose of conducting the main cases and the analysis technique. Second, it discusses the method used, including how the participants in the main cases were recruited, the description of the main cases, and how the $MTSF_1$ was applied to arrive at the recommended technology solutions. Next, the findings from the interviews are presented under two main themes: 1) technology and 2) pre- and post-experience. The technology theme includes the advantages and disadvantages of the current and recommended technologies. The pre- and post-experience theme consists of the relationships emerging from the technology theme. Then, the implications of the applied $MTSF_1$ and how these led to the next phase of refining the MTSF are explained. Finally, the $MTSF_2$ (Amended version of $MTSF_1$) is presented.

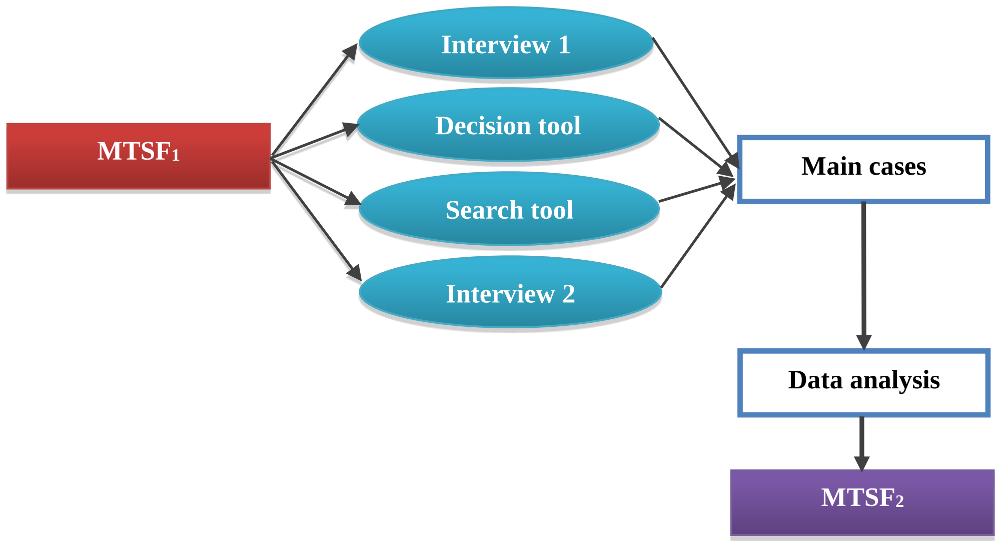

Figure 7.1. Phase 2 of the refinement of the Mainstream Technology Selection Framework (MTSF) by using the main cases

The purpose of the main cases is to refine the $MTSF_1$ by testing it with six cases. First, Interview 1 was conducted in Arabic to assess the abilities and needs of the participants. Then the researcher used the decision tool and search tool to allocate the appropriate technology solution for each case. Next, the recommended technologies were given to the participants to use for a period of time. Finally, the researcher conducted Interview 2 in Arabic to evaluate the effectiveness of the recommended technologies. The Interview 1 and Interview 2 for each of the cases were audio-recorded then transcribed and translated by the researcher to English. The first stage of analysis was conducted by coding the English transcripts using Nvivo 10. The researcher used grounded theory as an analysis technique. The second stage of analysis was conducted by categorising and revising the codes. The coding was done within and across cases to find patterns (Babbie 2010) and relationships. The coding does not connect the answers of a particular interview's question to a particular theme. However, wherever a piece of data was found in the interviews and it supported that theme, it was coded to that theme even if related to a different question. The analysis of the data follows the high level themes that have been drawn from the theoretical framework presented earlier in Chapter 4. The third stage was finding the relationship between themes. Finally, the findings represent the coding for each theme.

In some cases, participants' quotes are used in multiple themes. That happened for two reasons:

1. The participant's quote supported multiple themes because it had two or more different ideas.
2. It was not appropriate to split the quote because that would have affected the context required to understand the situation of the participant.

7.2 Method

Six participants have been recruited through a physical disability association in Saudi Arabia. In order to consider a person as a represented case s/he should satisfy the following criteria:

- Their age should be above 18 years to ensure their exposure to technologies and experience in dealing with it.

- In terms of the type and extent of disability, persons who have an upper body physical disability (without cognitive, hearing, or vision impairment) were chosen. The exclusion of multiple disabilities is done to facilitate the interview process.
- The persons should be able to communicate verbally, as the data collection technique employs semi-structured interviews, which require explanation and further discussion with the researcher.
- The persons have the desire to try new technologies and give their opinion about those new technologies.

The following is a description of each case.

7.2.1 Description of the cases

The six participants included two men and four women. The ages ranged from 29 to 56 (mean age 40). The length of time since having the disability ranged from 15 years to 30 years for four cases who acquired the disability in later stage of their life. Two cases had the disability since birth. Their ages are 29 and 35. The education backgrounds vary from high school to Master degree. In terms of stability of the disability all cases have gradually developed disability except two cases where the disability was caused by car accidents.

Table **7.1** presents information about the participants including their age, gender, type of disability, what technologies they were using before and after adopting the MTSF, and duration of using the new technologies.

Table 7.1. Information concerning the participants and technologies before and after adopting Phase 2 of refining the $MTSF_1$

Participants	Gender	Age	Type of disability	Technology before	Recommended technology	Duration of technology use
Case_1	Female	31	Muscular dystrophy	Desktop computer, iPhone	Microsoft surface pro 3 touch keyboard	3 weeks
Case_2	Male	50	Quadriplegia paralysis	iPhone	Tablet 10” track pad stand for the track pad holder for the tablet	2 weeks
Case_3	Female	37	Cerebellar Atrophy	Blackberry mobile	Galaxy Tab 7” Bluetooth keyboard	1 week
Case_4	Male	56	Quadriplegia paralysis	None	Huawei tablet 10” Bluetooth keyboard bed holder	3 days
Case_5	Female	29	Spinal muscular atrophy	None	August smart lock	(technology unavailable)
Case_6	Female	35	Quadriplegia paralysis	Laptop computer	Dragon Dictation application	1 week

Case_1 is a 31 year-old female. She has had muscular dystrophy since she was 15 years. She cannot move her legs and left arm at all. The only limb she can move is the right arm although with observed weakness. She also can move her head, however the motion is less than 180 degrees and without full control. For example she needs someone to help her return her head back to its normal position if it falls down to the back. In addition to limb weakness she also has shakiness in her arms. Her disability was gradually developed during the past 15 years. She lives with her family. She is very keen to her work as a secretary in an adult physical disabilities organization. She believes in helping people with physical disabilities to be more independent and successful in their life. She finished her masters a few years ago with many difficulties due to her disability. She wishes to have a technology which will make her PhD journey easier.

Case_2 is a 50 year-old male. He has quadriplegia paralysis caused by a car accident more than 25 years ago. His disability is stable since then. Different parts of his body have different levels of paralysis. He can move his neck. He can move his arms as well, however he has no control of his hands and fingers, which means he has lost the ability for fine movements. His legs are completely paralysed. Case_2 lives in a care facility because he depends on the person who takes care of him in most of his daily tasks. He works in a governmental sector and goes to work every day with assistant. He is also the founder of a physical disability organization which allows him to be aware of the situation and needs of the people with physical disability in Saudi Arabia. He did not finish his bachelor degree because of the accident, however he has a desire of being able to use a computer for different purposes.

Case_3 is a 37 year-old female. She has had cerebellar atrophy since she was 15. The disability started with difficulty in walking and gradually developed until she lost her ability to move her hands properly. She also has difficulty in speaking in an understandable way. Case_3 lives with her family and there is a carer who is responsible for her. She finished a bachelor’s degree in mathematics but because of her disability she cannot work. Initially, she worked from home as a websites supervisor for a while then she stopped. She is always looking for a better way of doing things in her limited world which is the table of her wheelchair. She already uses a mobile phone, but she desires the use of a smart phone with a touch screen.

Case_4 is a 56 year-old male. He has had quadriplegia paralysis as a result of a car accident 20 years ago. His disability has been stable since then. He cannot move his legs, however he has gross motor ability in his arms and hands with no fine motor co-ordination. Case_4 lives with his family. His wife and son take care of him. Before the disability he was working as an accountant. After the disability he could not even leave his home as the area where he lives was unprepared for wheelchairs. These circumstances increased his connection with his interest of reading books. He usually read books with an assistant, but he has a strong desire to be able to read books again without assistance.

Case_5 is a 29 year-old female. She has had spinal muscular atrophy since birth. Her disability gradually developed. She cannot stand up or hold something heavy. She also has a curvature in her back which causes pain in her back and left leg. She moves her arms and hands, but weakly. Case_5 lives with her family. She can depend on herself with some tasks such as eating and using her mobile, but needs an assistant with tasks that need strength such as opening a door. She finished high school and a course in computer science. She desires having more independence and privacy in her room by being able to open and close the door and control the lights and conditioner.

Case_6 is a 35 year-old female. She has had quadriplegia paralysis since birth as a result of medical error. She has dysfunction in her right hand, which makes eating and writing hard for her. She depends on her left hand to do most of her activities. Her leg motion is very limited. Case_6 lives with her family and she has a carer as well. She is doing a master degree. Her favourite thing to do is writing stories and books. She has published her first book. She also speaks three languages: Arabic, English, and Italian and has started learning French. She desires a faster way to type because currently she types using one finger of her left hand.

7.2.2 Procedures of applying $MTSF_1$

First, Interview 1 (the first instrument of the $MTSF_1$) was used to gather data from the main cases. The interviews were conducted at the participant's home or hospital. The semi-structured interview was used to guide the conversation between the participants and the researcher among the previously created themes and encourage the participants to give extended information.

Second, the data gathered in Interview 1 was transferred by the researcher to the decision tool. As the decision tool consists of the same theme as Interview 1, the data which was gathered under each theme in Interview 1 was transferred to the same node in the decision tool. Each branch in the decision tool ends with a feature of the technology solution. The technology features were detected based on the data feed from Interview 1. Refer to the steps of applying the decision tool in Phase 1 of refining the MTSF, Chapter 6.

Third, the search for the technology was started by using a search engine using key words. The key words represented the features obtained from the decision tool which started with detected type of the technology with the input preference. When the task and the input requirements were met, then the output preferences were checked. Once the technology met the task, input, and output requirements, the features of the technology which were generated from the environment theme were checked. The technology was adopted as a solution for the case, if it met all the features obtained from the decision tool.

Next, the technologies were sourced and given to the participants to use for a period of time. The participants were asked to keep a log of their technology use.

Finally, the researcher conducted Interview 2 with each participant, to evaluate the effectiveness of the recommended technologies.

7.2.2.1 *The application of the $MTSF_1$ for each case*

This section presents the matching summary. It includes the Interview 1 summary, application of decision and search tools, and the Interview 2 summary for each participant.

Case_1

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Task: Use computer keyboard by both hands	**Task:** faster typing	**Task + interaction method = main technology** Faster typing + hands = keyboard	**Goal achievement:** 96%
Current method **Advantages:** None **Disadvantages:** ● The device should be on the right side. ● My hand gets exhausted because I need to press hard on the buttons of the keyboard.	**Advantages:** None **Overcoming Disadvantages:** ● By using both hands to type, the position of the device will not be a problem anymore. ● Needing to overcome the pressing problem by using soft buttons or touch-sensitive buttons.		**Overcoming the difficulties:** I don't need any force to activate the keyboard buttons since they are touch sensitive.
Personal abilities ● Fair vision ● Excellent hearing and speech ● Poor abilities in the upper left side ● Very good abilities in the upper right side ● Poor to fair abilities in the lower body part. **Preferred interaction method** ● Both hands ● Eyes ● Shoulders	**Strongest body parts** ● Head ● Elbow ● Right Hand **Input specialization** ● Hands (touch) ● Input: Case_1 can move one finger in the left hand but she can't press buttons. Touch input considered as a solution. **Output specialization** ● Display (big screen/ text) ● Output: Case_1 has to be very close to the screen in order to see. She refuses to wear glasses the bigger screen or text should be considered.	**Main technology + input specialization = 1st words group of searching** Keyboard + touch or soft buttons = keyboard, touch, soft, buttons **1st words group of searching + Output specialization = final words group of searching** The output is not related to the keyboard itself so it had been checked in terms of the available screen.	**Pain and discomfort** Comfortable to use physically and emotionally.

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Environment • Indoor • Sitting position • Supported family • External design: important **Technology** • Small • Light • Easy to use • Long life battery	**Physical features** • Small • Light **Technical features** • Long/extra battery • Easy to use • Screen brightness: not applicable. **Privacy/ additional technology** • Not applicable. **People attitudes/ external design** • Normal or beautiful • Conspicuousness: not important.	• The candidate technology had been checked against the environment features • Once the technology satisfied the environment features it was considered as a solution.	**Technology effectiveness** • From 10 to 5 minutes to do the same task (less time) • Less effort (no need to press buttons) • No pain. • Use technology for other purposes (surfing internet, software for daily activities) **Technology customization** • Language barrier: the letters on the keyboard were in English. • Convert the device language • Adapted the device interface
The recommended technology:	Microsoft Surface Pro 3 with touch keyboard.		

Case_2

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Task: Using Twitter	**Task:** Access social network sites	**Task + interaction method = main technology** Access social network sites + voice = Tablet	**Goal achievement:** 70%
Current method **Advantages:** Enter into the world of the internet **Disadvantages:** Not accurate because I do not have the ability to control my hand to press the correct letter	**Advantages:** Emphasise the importance of social network site access. **Overcoming Disadvantages:** Needing to overcome the difficulty of fine movements, which important for writing by using more accurate method such as voice recognition.		**Overcoming the difficulties:** • Dragon Dictation app makes the writing easier. • Dragon has options to use text as tweet, SMS, Facebook status and email.

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Personal abilities ● Excellent vision, hearing and speech ● Good head control ● Poor abilities in the right hand. ● Completely paralysed in the rest of the body **Preferred interaction method** ● Head	**Strongest body parts** ● Eye movement ● Head **Input specialization** ● Voice ● Input: fine movements which are important for writing. Case_2 tried the head stick but he felt dizzy so the voice was considered as a solution although he preferred the head as an input method. **Output specialization** ● Display (big screen/ text) ● Output: Case_2 cannot bend his arm so the technology should be distant from him to be able to use it. ● The best position for Case_2 during the use of technology is lying on the bed so a holder for the technology screen on the bed is considered part of the solution	**Main technology + input specialization = 1st words group of searching** Tablet + voice = Tablet, voice, recognition **1st words group of searching + Output specialization = final words group of searching** Tablet, voice, recognition + big screen, big text	**Pain and discomfort** Comfortable to use physically and emotionally.
Environment ● Indoor / outdoor ● Lying / sitting position ● Supported family ● External design: important **Technology** ● Size and weight are not important ● Internet access ● Twitter app.	**Physical features** ● Size and weight are not important **Technical features** ● Internet access ● Supports the Arabic language **Privacy/ additional technology** ● Not applicable. **People attitudes/ external design** ● Normal (not attractive) ● Conspicuousness: not important.	● The candidate technology had been checked against the environment features (Internet access, Supports the Arabic language) ● Once the technology satisfied the environment features it was considered a solution.	**Technology effectiveness** ● Less effort (no need to delete and rewrite) ● No pain. **Technology customization** ● Accuracy barrier: adjust the cursor trails. ● Position barrier: adjust the trackpad position using a special stand
The recommended technology:	Tablet with a trackpad.		

Case_3

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Task: Access touch smart phone	**Task:** Using smart mobile phone	**Task + interaction method = main technology** Using smart mobile phone + hands = smart mobile phone	**Goal achievement:** 70%
Current method Advantages: ● Communicating with others ● Using Facebook and Twitter. **Disadvantages:** ● Inaccurate (lack of fine motor) ● Long time (many deleting and rewriting)	**Advantages:** ● Communication ● Using the wheelchair table **Disadvantages:** ● Need to overcome the lack of fine motor control by providing another way to access the mobile phone functions through big and distant buttons.		**Overcoming the difficulties:** The keyboard and the big screen made the use of the mobile phone easier.
Personal abilities ● Good vision and speech ● Fair hearing ● Excellent head and shoulder movement ● Good arm movement ● Poor hand and finger movement **Preferred interaction method** ● Hands	**Strongest body parts** ● Head ● Shoulders **Input specialization** ● Hands ● Input: Case_3 prefers to use hands as an input method. However, hands are weak so to consider hands; adaptation needs to be done, to enable her to use hands, such as attaching a keyboard with distant and big buttons. **Output specialization** ● Display and audio ● Output: Case_3 has difficulty to see the current mobile phone screen. Thus a big screen should be considered to solve this problem. Also, the volume of the device should be adjusted because she has hearing difficulty as well which leads to the use of an additional headphone instead of a speaker to provide privacy when she makes a call.	**Main technology + input specialization = 1st words group of searching** Smart mobile phone + big buttons = smart, mobile, big buttons **1st words group of searching + Output specialization = final words group of searching** Smart, mobile, big buttons + big screen = smart, mobile, big buttons, big screen	**Pain and discomfort** Comfortable to use physically and emotionally.

<table>
<tr><th>Interview 1 summary</th><th>Decision tool application</th><th>Search tool application</th><th>Interview 2 summary</th></tr>
<tr><td>Environment
Indoor
Sitting position
Support to some extent
External design: not important
Technology
Big screen
Big buttons
Light
Access to Internet
Has Facebook, Twitter and WhatsApp apps</td><td>Physical features
Big screen and buttons
Light
Technical features
Internet access
Easy to use
Facebook, Twitter and WhatsApp apps
Privacy/ additional technology
Bluetooth headphone
People attitudes/ external design
Conspicuousness: not important.</td><td>The candidate technology had been checked against the environment features
Once the technology satisfied the environment features it was considered as a solution.</td><td>Technology effectiveness
Easy to use mobile
Clear screen
Easy to use keyboard
No pain.
Technology customization
Keyboard is not 100% compatible with the smart phone however it is the only available choice
Connect the Bluetooth keyboard and headphone
Download Facebook, Twitter and WhatsApp apps</td></tr>
<tr><td>The recommended technology:</td><td colspan="3">Galaxy Tab 7”, Bluetooth keyboard and Bluetooth headphone</td></tr>
</table>

Case_4

<table>
<tr><th>Interview 1 summary</th><th>Decision tool application</th><th>Search tool application</th><th>Interview 2 summary</th></tr>
<tr><td>Task: Reading books</td><td>Task: Reading books</td><td>Task + interaction method = main technology
Reading books + hands = E-reader with keyboard</td><td>Goal achievement:
Progressive process</td></tr>
<tr><td>Current method
Advantages: I can turn the book pages when I sit and use a table
Disadvantages:
The text of the book is too small to see
It is difficult to open two books together</td><td>Advantages: set comfortably.
The technology can be mounted on the bed so Case_4 can use it while sitting.
Disadvantages:
The technology should have a magnifying feature or be connected to a big screen like a TV screen.</td><td></td><td>Overcoming the difficulties:
The device makes the text bigger so I can read easily.</td></tr>
</table>

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Personal abilities ● Excellent vision, hearing and speech ● Excellent head, arm, and hand movement ● Poor finger movement (can move only two fingers) **Preferred interaction method** ● Hands	**Strongest body parts** ● Head ● Arm ● Hand (two fingers) **Input specialization** ● Hands ● Input: Case_4 prefers to use hands as an input method. He can move hands and also can press buttons with two fingers so keyboard with distant buttons should work well with him as he can use the TV remote control easily. **Output specialization** ● Display and audio ● Output: Case_4 has difficulty to see the book text so magnifying feature should be considered or big screen.	**Main technology + input specialization = 1st words group of searching** E-reader, keyboard, distant buttons **1st words group of searching + Output specialization = final words group of searching** E-reader, keyboard, distant buttons, big screen	**Pain and discomfort** Comfortable to use physically and emotionally.
Environment ● Indoor ● Sitting position ● Supported family ● External design: not important **Technology** ● Light ● Has books and clips library	**Physical features** ● Light ● Big screen ● holder **Technical features** ● Books and clips library app **Privacy/ additional technology** ● Not applicable. **People attitudes/ external design** ● Conspicuousness: not important.	● The candidate technology had been checked against the environment features ● Once the technology satisfied the environment features it was considered as a solution.	**Technology effectiveness** ● Makes any book handy. ● Bigger text ● No pain. ● Use technology for other purposes (reading newspapers, listening, and watching soccer matches) **Technology customization** ● Connect the Bluetooth keyboard ● Download a library app
The recommended technology:	Huawei tablet 10”, Bluetooth keyboard and bed holder		

Case_5

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Task: Lock / open the door	**Task:** Lock / open the door	**Task + interaction method = main technology** Lock / open the door + hands = mobile application to control the door, compatible deadbolt	• The technology does not arrive yet. • Interview 2 for Case_5 had not been completed.
Current method **Advantages:** None **Disadvantages:** • Lack of privacy. • Lack of independence (Ask someone to lock the door and come back later to open it).	**Advantages:** None **Disadvantages:** • Need to overcome the privacy and independence issues by gaining the benefit of her ability of using her mobile phone easily and being with her all the time.		
Personal abilities • Excellent vision, hearing and speech • Very good head movement • Good shoulder and arm movement • Excellent right hand and finger movement • Good left hand finger movement • In general the left side of the body is weaker than the right **Preferred interaction method** • Hands	**Strongest body parts** • Right hand **Input specialization** • Hands • Input: Case_5 prefers to use hands as an input method. No need for any input specialization because she can use her mobile touch screen by her hands easily. **Output specialization** • External output	**Main technology + input specialization = 1st words group of searching** Mobile application to control the door, compatible deadbolt (no input specialization) **1st words group of searching + Output specialization = final words group of searching** External output (no output specialization)	

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Environment ● Indoor ● Sitting position ● Supported family ● External design: important **Technology** ● Light ● Control the door	**Physical features** ● Light **Technical features** ● Not applicable. **Privacy/ additional technology** ● Compatible deadbolt. **People attitudes/ external design** ● Normal or beautiful ● Conspicuousness: not important.	● The candidate technology had been checked against the environment features (compatible with the door lock). ● Once the technology satisfied the environment features it was considered as a solution.	
The recommended technology:	August mobile application with its compatible deadbolt		

Case_6

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Task: Typing	**Task:** Typing	**Task + interaction method = main technology** Typing + voice = voice recognition software	**Goal achievement:** 60%
Current method **Advantages:** None **Disadvantages:** ● Difficulty using the laptop touchpad. ● Difficulty using the external mouse	**Advantages:** None **Disadvantages:** ● Keep losing the cursor. ● The external mouse keeps breaking ● Need to overcome the stress Case_6 feels when using touchpad, mouse, and keyboard by switching to voice to text feature.		**Overcoming the difficulties:** ● Send text messages faster. However, the number of mistakes increases if I say more than two sentences. ● More flexible and save time

Interview 1 summary	Decision tool application	Search tool application	Interview 2 summary
Personal abilities • Good vision • Excellent hearing and speech • Excellent head and shoulders movement • Very good arm movement • Excellent left hand and fingers movement • Good right hand and fingers movement **Preferred interaction method** • Voice • Left hand	**Strongest body parts** • Head • Left Hand **Input specialization** • Voice • Input: to guarantee the accurate input Case_6 should use a microphone. **Output specialization** • Display • Output: No output specialization	**Main technology + input specialization = 1st words group of searching** The voice recognition software is an input method itself. **1st words group of searching + Output specialization = final words group of searching** No output specialization	**Pain and discomfort** Comfortable to use physically. However, I just feel frustrated when the application writes the word wrong.
Environment • Indoor • Sitting position • Supported family • External design: at least reasonable **Technology** • Reasonable size and weight	**Physical features** • Reasonable size and weight **Technical features** • Support Arabic language. **Privacy/ additional technology** • Microphone **People attitudes/ external design** • Reasonable • Conspicuousness: not important.	• The candidate technology had been checked against the environment features (support Arabic language). • Once the technology satisfied the environment features it was considered as a solution.	**Technology effectiveness** • Save time • Flexible • Easier **Technology customization** • Download the voice recognition software
The recommended technology:	Dragon Dictation application		

The next section presents the findings from analysing the responses of the participants in Interview 1 and Interview 2.

7.3 Findings analysis

The findings are divided into two high level themes. The first theme relates to the technology and presents the advantages and disadvantages of the technologies before adopting the MTSF and the recommended technologies after adopting the MTSF. The second theme relates to the experiences of individuals, both before using the recommended technologies and after having used the technologies. The analysis of the findings was conducted against the conceptual framework.

7.3.1 Technology

In the literature on matching a person with a disability and a technology the technology was considered as an external factor. However, it is represented in the findings as an independent theme because it represents the core of this research and it is also a separate concept in activity theory which is the theoretical framework used for this research.

7.3.1.1 *Technologies before adopting the MTSF*

The next two sections present the findings regarding the advantages and disadvantages of the technologies that were used by the participants before adopting the MTSF by the researcher. Table **7.1** shows the old technology for each case in the fourth column (Pre-Technology).

Value of technologies currently used

To explore the value of usefulness of the technologies recommended to participants it was important to first establish what if anything participants were currently using. Participants were asked a number of questions relating to this, including the types of technologies they were using and the benefits that they got from using those technologies.

There were only a few advantages of the old technologies and those due to three reasons:

- Two of the participants never had to use any technology for the goals they had stated in the first interview.
- The participants in general found the technologies that they currently used were not effective for achieving the goals that encouraged them to participate in this research.
- There was lack of awareness from the participants of what technology can offer for people with disabilities.

Mainstream technologies have many features that can make access easier. For example, some smart phones have the ability to convert the list of contacts to small pictures or icons on the home screen, which can be easier to access for people who do not have fine motor control such as Case_2. Awareness of technology features enables people with disabilities to gain benefits from these options. The technology offers new opportunities to interact in a variety of ways.

Case_2 uses his smartphone to make calls he found. Providing a fast access list of the important contacts on the home screen helped him to save time and have more control.

> *"The easiest way of using my mobile is to make a call, because all names are ready for me." (Case_2)*

In addition, the availability of different choices is an encouraging factor to continue using the technology. Case_3 worked as website supervisor in the onset of her disability, using her smart phone to do the job. However, because she has a cerebellar atrophy, which is a progressive disability, she started losing control in her fine motor skills and became unable to use the smart phone any more. The better choice for her was a device with bigger buttons. This meant that she moved to use a computer keyboard.

> *"The computer use is easier for me because the buttons are bigger." (Case_3)*

As her disability progressed she completely stopped her work. To the best of her knowledge there were no other ways to access her computer or smart phone. This misperception shows how important it is to have support specialists who have effective processes to match people with disabilities with appropriate technologies, especially considering the changes in their abilities and needs.

Disadvantages of technologies currently used

As part of establishing baseline knowledge about the technologies that were used by participants, they were also asked a number of questions relating to the difficulties that they faced when using the technologies.

Most difficulties that were faced by participants while using the old technologies related to access methods (input devices) are time, effort, positions of the technology, and the negative emotions. The next section explains these difficulties along with examples from the participants' responses.

Time needed to get the task done

Time needed to finish the task is a crucial point to evaluate the effectiveness of the technology used, especially when the task is related to daily or primary needs such as communication with others. Case_2 mentioned the long time that it took to write and send a text message to his family or workmates while using a stick attached to his head as an input method.

> *"Using this stick or pen was hard for me. Also, in my mobile if I want to write a text message of ten words. For example, if I want to press the letter A, I press the letter B. After that, I have to delete B and try to press A again for many times of trying to press the correct letter. This is because I don't have the control or ability to control my hand to press the correct letter."* (Case_2)

This illustrates that people with disabilities consider the time to achieve a task an important factor that affects whether there is continuing use of the technology. Case_2 stopped using the stick to write messages on his mobile and preferred to use his hand again as there was no improvement in his performance. Thus, even though technology may be specifically developed for people with disabilities that does not mean it can help them in achieving their goal at a usable level. The MTSF addressed the issue of achieving the goal in Interview 2. It includes questions about whether the desired goal has been achieved or not and the effectiveness of the recommended technology in achieving that goal.

Physical effort such as pain and exertion

Physical effort for people with disabilities is an important issue, as continuing the same motion for an extended period could lead to pain. In some cases, the person with disability does not have a choice but to focus on using a specific part of his or her body to interact with the technology because this part of his/her body is the only part over which s/he has adequate control. However, this can lead to exhausting that body part. Case_1, as an example, is a secretary who needs to use the computer with an old keyboard all the time. She stated regarding the effort she needs to put on to use the old keyboard:

> *"With my old keyboard I have to make an effort to press the buttons which causes me pain in my hands at the end of the day."* (Case_1)

Moreover, she does not have control of her left hand. This forces her to use her right hand all the time at work and home as well and that causes her hand to be exhausted as she mentioned:

> *"I don't see any advantage in the current way of typing because I rely on one hand. At the end of the working day when I go back home I can't use my hand to eat because it's exhausted."* (Case_1)

As is obvious in this case, a mainstream technology had been used which is a computer keyboard. However, the choice of a keyboard type played a crucial rule in the problem faced by Case_1 because activating the buttons of the keyboard should be easier and more flexible. That is not impossible given the plethora of different types of keyboards available. It is also worthwhile mentioning that taking Case_1's abilities into consideration can lead to a better technology choice for her. The Interview 1 and the decision tool in the MTSF do take abilities into consideration. During Interview 1 detailed information about the abilities of the person is gathered. Then the decision tool detects the suitable features of the technology to meet the abilities of the person. Furthermore, the decision tool detects any customization requirements to provide the most comfortable option for each case.

Position of the technology for the person with disability

Some of the people with disabilities who use technology at work or in public places are faced with the problem relating to the position of the technology. For example if the technology is on the side of their body which has the disability and they cannot adjust the technology placement to meet their needs, they will not be able to use it. In the best case they will use it uncomfortably. Case_1 who has a disability in her left hand cannot use the keyboard in her workplace unless she sits in front of her desk with the right side of her body against the desk.

> *"The device should be on the right side of my body otherwise I can't use it. I also cannot use a keyboard that needs hard pressing on the buttons." (Case_1)*

Technology positioning should be adjustable in order to create the most comfortable way of interacting with the technology. This could be as simple as the position of the keyboard on the table or the wall. Even with technology designed to be adjustable, some additional hardware such as holders can make the user even more comfortable. The MTSF addressed this issue in Interview 1 by gathering information about the environment where the person intended to use the technology and also about the preferred position.

Negative emotions such as stress and frustration

As long as the person with disability has control of the technology and can smoothly interact with it to achieve what s/he expects from it, the stress and frustration will be avoided. That means spending more time using the technology with a better experience of achieving the goal. An input device is the first station in interacting with the technology. For Case_6 she uses a touch pad to interact with her laptop however because she does not have control of the fine motor coordination in her fingers and also due to the small size of the touch pad she cannot use it properly, causing negative feelings as she points out:

> *"The touch pad of the laptop is the most stressful thing because I keep losing the cursor on the screen. I tried to use an external mouse but it keeps breaking even though it is more comfortable." (Case_6)*

Negative feelings about the technology use-experience can lead people to stop using the technology or reduce the time they spend on it. Thus, it is really paramount to examine the feelings of the person with disability during and after the use of the technology in order to explore the source of negative feelings. This issue has been captured in the MTSF, Interview 2. Interview 2 includes questions about the physical and emotional difficulties that the person with disability may face during use of the recommended technology.

7.3.1.2 *Technologies after adopting the MTSF*

The following two sections represent the findings regarding advantages and disadvantages of the new technologies which were introduced by the researcher to the participants after adopting the MTSF to select the appropriate mainstream technology for each case. Table **7.1** shows the new technology for each case in the fifth column (Post-Technology).

Value of recommended technologies

As mentioned previously in the section on disadvantages of the old technologies, most difficulties that the participants faced were around the input methods. Consequently, the new technologies have been chosen to overcome the difficulties with the input methods.

After introducing the new technologies to the participants and them having the opportunity to use those technologies for a period of time, they appreciated different things such as ease of use, effectiveness, tolerance of input and output channels, diversity of mainstream technology features, social acceptance, and how much more independent they became after using the technologies. The next sections explain these issues along with quotes from the participants' responses.

Alternative method of Interaction

For example Case_2 was trying to use a stick attached to his head for typing on the computer. However, because he is completely paralysed this was ineffective. The new technology used the voice as an input method instead of his head. This avoided lack of control and prevented discomfort from the previous method. He describes his experience with the new technology using voice recognition:

> *"To be honest, accessing Twitter from my iPhone is easier because I used the Dragon Dictation app which makes the writing easier. Also Dragon has options to use the text as tweet, SMS, Facebook status, and email." (Case_2).*

Giving the input method enough priority affects the whole experience of using the technology. Case_2 was despondent about his ability to access any technology until he tried the voice recognition input method. The MTSF evaluates the abilities of the person with disability, which helps later to choose the appropriate input method to ensure the maximum comfort for the experience. Voice recognition is a mainstream technology which is available as an input method choice in many smart phones, or as an application sometimes there are even free options such as the Dragon Dictation application on the iPhone.

Effectiveness

Participants mentioned the effectiveness of the new technologies which is the degree to which the technologies are successful in achieving their goals. The effectiveness includes completing the task within the expected time without major problems. Case_2 explained how the application of the voice recognition on his iPhone helped him to write and fix the mistakes effectively:

> *"It is effective by more than 70%. When I found the Dragon Dictation app on the iPhone I focused more on it because I can write using my voice and also I can fix the incorrect words. Moreover, when I focus my voice, the number of mistakes gets smaller." (Case_2)*

Because Case_2 felt that the voice recognition can undertake the writing task for him, he continued to try to find new ways to improve the application's performance such as using a microphone and working on his pronunciation to reduce mistakes.

Case_3 also mentioned that using a smart phone with a big screen and an external linked keyboard instead of her old smart phone (Blackberry) helped her use Facebook and Twitter more frequently. The Blackberry is the only smart phone with a keyboard that she can use. She has difficulty using a smart phone with a touch screen due to the lack of fine motor coordination and jerking in her hands

> *"The technology is good. It overcomes the size of the keyboard buttons and the screen by 70%. I even spend more time on Facebook and Twitter." (Case_3)*

The time taken to complete the task is also a strong indicator of the effectiveness of the technology being used. Case_1 stated that after using a touch sensitive keyboard instead of the traditional keyboard she could finish her work tasks faster than before:

> *"I was spending 10 minutes to finish a letter for my work. Now I just need 5 minutes to do the same task." (Case_1)*

Case_6 also mentioned that the voice recognition software on her iPhone allowed her to type faster than using her hand, which saved time.

> *"Writing on the computer using speech to text software (Dragon Dictation) is more flexible and saves time." (Case_6)*

Case_1 used a tablet with a touch sensitive keyboard at work to do writing tasks and even outside the workplace on other tasks that she did not indicate as goals in the first interview

> *"I used the device to type at work. I used it also to surf the Internet. I have downloaded software for daily activities as well." (case_1)*

Another example of using the technology assigned in other tasks that were not mentioned as goals in the first interview is Case_4. He said that his main goal was to be able to read books again. However, he used the technology to read books, watch lectures, and view video clips such as soccer games.

> *"I see the device so good for me. I even saw a soccer match last night." (Case_4)*

Feeling that the technology is effective (as measured by the success in completing the task, the time taken to complete the task, or being able to use the technology in multiple tasks) encouraged the person with disability to explore the technology further to extend improvements in the results s/he gained. The MTSF clearly identifies the participant's goals, which in turn enables selection of technology that can complete the task effectively. In addition, the MTSF detects difficulties or advantages in the old technology so that these can be considered during the selection process of the new technology. By overcoming previous difficulties and gaining benefit from any advantages, the effectiveness of the new technology can be maximised.

Independence

Being independent is an important priority for people with disabilities. The responses of the participants are varied but most of them emphasized that they became more independent after using the new technologies.

Case_2 pointed out that he still needed someone to put the device on the bed for him and turn it on for him because it requires a button press that he is unable to do. However, he stated that he can do 60% of the task including the main part which is the writing.

> *"I depend on myself 60%, my ambitions was 30%. However, I still need someone to help me." (Case_2)*

Becoming independent can be a gradual process. By using the technology, a person becomes more independent, because persistently using the technology increases the opportunities to explore more of the technologies features and learn how to do things faster such as using shortcuts. When Case_4 started using the tablet which is mounted on his bed with a physical keyboard, he needed constant assistance to learn what each button does. However, using the device nearly all day improved his knowledge regarding using the technology and he became more independent.

> *"There was a help at the beginning but it gets less and less." (Case_4)*

Understanding exactly where the person with disability needs help in doing the task gives clear idea about the features of the technology. The MTSF collects detailed information about the tasks and how the person previously completed them, including what parts of the tasks s/he can do and what parts are hard to achieve independently. This information is used to determine what modifications would enable him or her to do most of the task parts independently. This could, for example, involve the installation of extra applications on the technology or external technology such as a holder to keep the other technology within reach of the person.

The ease of use

Selecting the technology that is easy to use depends on several things according to the MTSF. First, the level of technology knowledge the person with disability possesses has, plays an important role in the selection process. When the person with disability gains experience by using technology, the range of choices will be wider and easier. Second, the type of the task the person with disability desires to perform is also important. Mostly, the technology will be easier to use if it is designed for just one task. The more features the technology acquires as it gets more complex, the harder the navigation task of the novice user. Consequently, selecting the technology that only has what the person with disability needs with minimum extra features is important to keep the technology simple and easy to use, encouraging the person with disability to continue using it. Finally, considering the abilities of the person with disability provides an easy-to-use technology solution. The abilities of the person with disability must be given priority as the person's abilities define the easiest way of interacting with the technology.

Case_4 does not have any experience in using technology. The main goal for him is to be able to read again as the books' texts are too small for him to see. The simplest and obvious mainstream technology solution for him is an E-Reader which focuses on the main goal (reading books) and has minimum features. However, due to unavailability of the E-Reader in the city where he lives and the desire to implement the plan in a timely manner, the tablet had been used to do the job with an application to download the books that he likes to read. Case_4 found the use of the tablet hard at the beginning and that is due to lack of technology experience. However, the passion he has for reading encouraged him to use the tablet more often which improves his technology knowledge and making the use easier by time

> *"Actually it is a progressive process. At the beginning, the use was hard but the more I use the device the more it gets easier." (Case_4)*

When a person with a disability feels that his opinion is considered and feels that he has control of the selection of the technology, it reinforces his desire to try the technology and give suggestions to improve the performance, to make the technology easier for him to use.

Case_4 tried two options of interaction methods: external physical keyboard and touch screen keyboard. Then he chose the easier option in terms of his abilities as he stated:

> *"I found the use of the physical keyboard is much easier because I have more control of the speed of my fingers." (Case_4)*

Case_2 also emphasised the importance of considering the person's abilities to provide an easy to use solution. He was almost completely paralysed and used his thumb joint to hit the letters on his iPhone screen, which was not accurate. The external touch pad which was attached to a tablet along with mouse features adjustments improved his accuracy and made the access of the tablet easier than the iPhone touch screen.

> *"The device is easy to use so it is better than the iPhone." (Case_2)*

The MTSF takes the level of the technology knowledge of the person with disability, the type of the task, and the person's abilities into consideration before selecting the technology. This makes sure that the mainstream technology solution balances the level of knowledge and the features to achieve the goal with a minimum level of complexity and difficulty. In addition, most of the participants emphasised the feasibility of the mainstream technology solutions to make achieving their goals easier.

Diversity of mainstream technology features

Technology features include hardware features and software features. Hardware features relate to the external design of the technology such as size, weight, and colour. The software features relate to performance and functionality such as language support, battery life, and Internet access. Moreover, there are some features that are related to hardware and software such as compatibility. The compatibility is defined in the research as: the consideration of the other technologies that the person with disability might have already so the recommended technology (software of hardware) can be compatible with them.

The person with disability is supposed to deal with the technology directly. In other words the assistance required to move, operate, and use the technology should be minimized. The task and the abilities of the person with disability are the main guides for choosing a technology with appropriate hardware and software features.

Case_2 was using Twitter on his iPhone and he complained about the size of the screen as the iPhone had to be placed a specific distance from him because he cannot bend his arm.

In this case, bigger sized technology means a bigger screen. Thus, providing another technology (tablet) with a bigger screen, Internet access, and Twitter application solves the problem.

> *"The screen is big. It is like a desk top. The screen of the iPhone is so small." (Case_2)*

For Case_4, size and weight of the technology are not important considerations since he cannot travel outside home or even move around inside. However, the importance of external features such as the size came from his need for big texts, to be able to read books. He appreciated the size of the tablet which is mounted on his bed and a feature that gives him the ability to increase the size of the texts as he needs

> *"The device makes the text bigger so I can read easily." (Case_4)*

On the other hand, traveling with the technology increases the need to consider the size and weight of the technology. Due to the need of Case_1 to use a computer at home and work and the weakness of her muscles, the size and the weight are very important. A tablet that meets her needs will have all the functions of the desktop computer while being smaller and lighter.

> *"It is smaller and lighter than my old one. It allows me to do the same tasks faster." (Case_1)*

Furthermore, traveling with the technology also increases the need to consider other features of the technology. For example In terms of the hardware features, the battery life is a vital feature especially for someone like Case_1 because she needs to travel with the technology between home and work and do some work in the car.

> *"I just need to charge it once a day. Mostly I do that at night." (Case_1)*

Case_1 valued the technology being able to function all the day with just one charge, whereas this would not be important for Case_4.

Most of the participants do not have previous high level technology knowledge, which makes it hard for them to figure out the software features that might help them to achieve better results. However, some participants implicitly mentioned software features that related to the ability of some applications such as that some applications function better on the recommended technology

> *"For example Facebook, it is the same on both devices but on the new device it is easier because I can see the whole page at once. Also the pictures were not appearing on my old device." (Case_3)*

Mostly, the application functions better when it is compatible with the operating system of the technology and this is what happened for Case_3. The updated version of Facebook did not work well on her old technology (Blackberry mobile) because it was not compatible with the version of the operating system.

Compatibility as mentioned previously is a feature that related to hardware and software. The example of Facebook is related to software compatibility. Case_1 pointed out that she was able to connect her iPhone headset to the new technology (tablet) and it worked perfectly. This is another example of hardware compatibility.

> *"I used my iPhone headset and it works well with the device." (Case_1)*

Hardware and software compatibility was also obvious when Case_1 connected the tablet with the printer in her office which allowed her to save time and effort because she was sending her work to her email to open and print from the old desktop computer.

> *"My brother brought me a cable which connects the device directly to the printer." (Case_1)*

If the people with disability discover that they can achieve their goals using the old technology or part of it, they feel more confident and comfortable because they get used to the technology and know how to use it. Case_6 was facing a difficulty in typing on the traditional keyboard because she used one finger to do that. The mainstream technology solution was a voice recognition application (Dragon Dictation) which installed on her smart phone (iPhone)

> *"The software works on my iPhone. I have got used to it and take it with me everywhere." (Case_6)*

Technology features contribute to the most important part in the matching process because providing the appropriate features that meet the person's needs will facilitate the whole interaction experience. The MTSF gave this part special attention. First, gathering detailed information about the goal that the person wants to achieve helps to choose the technology that achieves that goal in the easiest way. Second, gathering information about the physical senses' abilities helps choose the best matching methods (input and output). Finally, gathering information about the experience of technology in general and any technology that had been used helped to choose the level of complexity of the technology and consider the compatibility of the recommended technology with the old ones.

Social-environment friendly technology

Social-environment friendly technology is the technology that can be used in public places easily, comfortably, and without feeling embarrassed. Due to that the technology solutions which have been used in this research are mainstream technologies such as smart phone, tablet, track pad, keyboard and applications installed on the smart phones. Most of the participants feel confident to use the technology solutions in public places.

Case_1 gave the look of the technology a high priority over the task effectiveness

> *"To be honest, I will not be lying. I prefer technology that meets 60% of my needs and looks normal or beautiful more than technology that meets 100% of my needs and looks specifically designed for people with disabilities." (Case_1)*

Her goal was to be able to type on the computer using her both hands. Because of the loss of the hand's muscle strength the sensitive touch keyboard was a perfect solution for her as she mentioned

> *"I can say with confidence that this device help me 96% to achieve my goal" (Case_1)*

The light, thin, and pink keyboard means a lot to her.

> *"It is easy to use and looks beautiful." (Case_1)*

This case shows the ability of the mainstream technologies to provide a balance between achieving the main goal and other needs of the person with disabilities. The mainstream technology can be proficient and beautiful as well.

Sometimes having beautiful technology exceeds satisfying personal needs. It also includes how other people look at the person with disability and his/her way of doing things. For Case_3, having technology that at least looks like the technology in others people hands encourages her to take the technology outside home.

> *"It is good, if I can use it outside. I will not be embarrassed." (Case_3)*

Being embarrassed of using the technology in public places occurs because the people with disabilities feel that they use different technologies than others. Consequently, they feel that using different technologies are a strong factor in attracting attention to their disabilities. Thus, providing mainstream technology solutions for them assists them to overcome this feeling and to be more confident.

Barriers which prevent people with disabilities from using technology in public places may be social or environmental barriers. Part of the appearance of the technology can overcome social barriers, enabling travelling with technology easily and comfortably in different places. The technology thus also overcomes environmental barriers successfully. Case_1 was able to use her tablet in home, office and even during the journey between them.

> *"I can use the device everywhere even while on my lap, but not for typing because I need a table for that." (Case_1)*

Case_6 pointed out that her experience of using the voice recognition application (Dragon Dictation) on her smart phone at university does not constitute any privacy barriers.

> *"I used it outside and I did not face any privacy problem." (Case_6)*

To overcome any social or environmental barriers, adequate information about where the person with disability intends to use the technology should be collected. In addition, balancing the preferences and the needs of the person with disability is a crucial step in choosing the appropriate technology. The MTSF provides mainstream technology solutions which rarely create social or environmental barriers because mainstream technologies are widely accepted and used by various segments of society. However, the MTSF considers the social and environmental requirements, to offer the most appropriate technology solution.

Tolerant input/output channels

As has been mentioned in the negatives of the old technology section, the most common difficulties were related to the interaction with the input/output channels. Most of the participants experienced input/output difficulties. The difficulties which related to input/output channels include: physical difficulties such as pain and exertion and emotional difficulties such as stress and frustration. After using the new technology, most of the participants pointed out that the new technologies assist them to overcome these difficulties.

Case_2 was having difficulty using the touch screen to write messages. However, replacing the touch screen as an input channel with a touch pad and adjusting mouse features assist him to overcome writing difficulties.

> *"I didn't face any physical difficulty. Emotionally, it is comfortable when I have time." (Case_2)*

The main goal of Case_4 is to be able to read books again. The recommended technology for him was a tablet which was mounted on his bed and a Bluetooth keyboard to browse books. For someone who has never used technology before, having a mainstream technology that is physically and emotionally comfortable to use is an appreciable advantage.

> *"It is really comfortable. I never have any pain." (Case_4)*

Case_1 completely dispensed with the need to press the buttons on the traditional keyboard by using a touch sensitive keyboard which eliminated her previous pain.

> *"The new device solved this problem because I don't need any force to activate the keyboard buttons since they are touch sensitive, so no pain with the new device." (Case_1)*

Case_3 also stated that using the bigger and separate keyboard with a bigger smart phone instead of her old smart phone (Blackberry) does not cause any pain or physical difficulty.

> *"It is comfortable - no physical or emotional difficulties" (Case_3)*

The physical and emotional difficulties that prevent the participants from using their old technologies were considered in the MTSF. The MTSF deals with these difficulties in two stages. The first stage is in the first interview by gathering information about any type of difficulties experienced by the participants while using the old technologies. Then, the MTSF tries to overcome these difficulties in the new recommendation. The second stage involves the second interview but this time the MTSF checks if difficulties remain or new difficulties were introduced from using the new technologies.

Unexpected advantages

Apart from the technical advantages which were presented in the last sections, there are unexpected advantages that were mentioned by the participants. These advantages related to the physical abilities of the participants and how the mainstream technologies helped them improve their motor skills.

Case_4 was not able to move his fingers. However, he could move his hands and arms at once. Thus, he did not have fine motor skills in his fingers, preventing him from using a touch screen. The mainstream technology solution for him was a Bluetooth keyboard which is compatible with the tablet. The keyboard has big and separated buttons to overcome the weakness in the fine motor skills. This solution was derived from his success in using the television remote control. After using the keyboard for a while he expressed that using the keyboard reactivated some of the fine motor skills in his fingers

> *“It helps me move my fingers. It is like exercises. It makes my fingers more active than before.” (Case_4)*

In the same context, Case_1 in the first interview was frustrated by not being able to use her left hand to type even though she could move her hand. The only problem was the force she needed to exert to press the buttons. After using the sensitive touch keyboard she stated

> *“The most important thing is that I can use my left hand again. The device helped me to reuse my left hand effectively.” (Case_1)*

Case_1 did not expect that she would be able to use her left hand again. However, the MTSF provided a technology solution that balanced the person’s needs and abilities through the decision tool to get the benefits of what the people with disabilities already can do.

Even though the goal of the MTSF is not to improve the physical performance of people with disabilities, there are some indicators that mainstream technologies can work as motivators to help these people get the most from their abilities. Consequently, the participants were surprised sometimes with their abilities to use the recommended technologies.

Disadvantages of recommended technologies

The last section discussed the possibility of mainstream technologies to be alternative solutions for people with disabilities. Although most of the participants’ responses demonstrate many advantages of the mainstream technologies, there are negative responses that show some disadvantages of the mainstream technologies. These negative responses will be discussed in this section.

Dependence in some parts of the task

Due to the nature of the physical disabilities of the participants, complete independence was not achieved. However, participants show significant improved levels of independence as presented in Subsection (Independence).

Preparing the technology is one of the difficult parts for people with disabilities. However, using technologies enables them to do tasks they would not be able to do otherwise. Preparing the technology includes installation and positioning, operating, and feature adjustments. It starts with installation and positioning the technology to be within the reach of the person, which includes potentially mounting the technology on a holder on a bed or wheelchair. Then activating the technology if the person with disability cannot do that for example if the starting process includes pressing hard on buttons. During the installation process, sometimes the technology needs feature adjustments such as cursor trails or screen brightness. That has to be done before the person with disability becomes able to use the technology.

The step of positioning and starting was a drawback for Case_2 because he is completely paralysed. The tablet that he uses needed to be installed on a holder and then placed on the bed. He said that his assistant is the one who does the positioning part for him, so when his assistant is not available he cannot use the technology at all

> *"It is much easier in terms of use but not in terms of the time that it needs to install. I have to put the tablet on the holder and I have to be on the bed to be able to use the device. I don't have the ability to do all of these things, especially as my carer most of the time is not with me." (Case_2)*

For Case_4 as he is not able to move from his bed the installation part does not constitute any problem because the tablet is mounted on his bed all the time. However, starting up the technology is a drawback for him because he cannot bend his arms and hands

> *"I need someone to turn on the device for me because the button is at the back." (Case_4)*

Sometimes balancing the needs of the people with disabilities and their abilities is a precise process because even with providing the technology with all required features that meets the person's needs, the abilities of the person still might not cope with all aspects of the technology use. Case_1 as an example needs a technology that has all the features of the desk top computer but smaller and lighter than the normal lap top so she can travel easily with it. The Microsoft surface tablet perfectly does the job, however because it is considered a mini computer it is still heavier than a normal tablet. In addition, due to her muscle weakness she cannot in any way move the technology

> *"I still need someone to take it out of my bag or move it to another place." (Case_1)*

Given Case_1's circumstances the technology achieves 96% of her goal as she stated previously. However, solving the problem of moving the tablet by mounting the technology on her wheelchair so she does not need to move it may solve her problem especially outside home.

Considering all parts of a task gives a clear idea of where the person with disability needs help and where s/he can be independent. The MTSF gives this point special consideration. The MTSF gathers information about how the person with disability currently does the task. If s/he needs any kind of help to complete it, the MTSF recommends a mainstream technology that reduces the dependence as much as possible. In addition, after the use of the recommended technology a follow up interview finds out any dependence with the new technology such as with Case_1 above. Although the MTSF gave independence special consideration, some parts of the task still could not be done by the participants. That is due to the nature of their disabilities (such as Case_4 above) or their preferences (such as Case_2 above). For example, when a wheelchair holder was recommended for Case_2 to reduce the dependence of installation and increase the ability of using the technology in more places, he refused because he thought that would attract attention:

> *"Even if I can take it with me everywhere it is still big and attracts the attention of others and I don't want that." (Case_2)*

The difficulty of providing some technologies

The time limitation minimized the choices of the mainstream technology solutions because some of the technologies are not available in Saudi Arabia and while they could be ordered from other countries they could take more than 5 months to arrive. For example, the E-reader was the technology solution for Case_4. However, because the researcher did not find E-readers in the city where Case_4 lives the technology solution changed to a tablet with a library application. Thus, Case_4 can download the books he likes and be able to read.

Another example was Case_5. The technology solution was a smart lock for her room door which can be controlled by using her smart phone. Again this technology choice was not available and has been ordered from USA and not arrived yet. That explains why Interview 2 for Case_5 has not been completed.

These two examples seem to be against the argument of this research which is that the mainstream technologies can be affordable and available alternative solutions for people with disabilities. However, being able to find another mainstream technology solution which worked perfectly and successfully such as in Case_4, strongly supports the argument and illustrates the idea of the variety of mainstream technology features which offer several technology choices for the same case.

A number of reasons for the limited implementation of technologies in Saudi Arabia were presented in Chapter 2 of this research.

Lack of language support

Most of the mainstream technologies support the English language. Even though some of the technologies support other languages, there is still a lack of support of the Arabic language which is the first language of the participants in this research. The lack of mainstream technologies which support the Arabic language is a huge obstacle in the process of providing appropriate mainstream technologies for the participants. This obstacle is obvious in some cases such as Case_1. The mainstream technology solution for her was a tablet with a touch sensitive keyboard. However, the available touch sensitive keyboard was with English letters

> *"The letters on the keyboard were in English so I put Arabic letter stickers on top of them. The screen is smaller than my old computer so it needs more concentration to see, but I get used to it." (Case_1)*

The MTSF did not consider language support in the first version. However, after Case_1 faced this problem with the language the MTSF was amended to consider language support under the technology features.

The need for training

As mentioned previously most of the participants do not have a high knowledge in using technologies. Thus, they need time to learn how to use the recommended mainstream technologies, especially when they have been used to their own old technologies and find it difficult to change. The biggest problems in the training process are time and trainers. In terms of the time, the people with disabilities have their jobs and families and it is hard for some of them to find time for training sessions.

The participants with less technology knowledge are the people who need the most training such as Case_4. He never used any technology for reading but his passion to read again encouraged him to be the trainer of himself even if the use of the technology was hard for him in the beginning

> *"The use was hard but the more I use the device the more it gets easier." (Case_4)*

For Case_2 the situation was better because he was already used to his smart phone (iPhone). Even though Case_2 did not use his smart phone to access Twitter, being used to the technology itself is considered an advantage in comparison with being trained by someone on completely new technology. However, he still needs some training to be comfortable navigating the Twitter application.

> *"It needs time to learn and train to use the device properly." (Case_2)*

Without having that proper and adequate training the person will find the use of the technology difficult which is a strong factor to stop using the recommended technology. Although, the training is out of the scope of this research it is still worthwhile to mention any disadvantages faced by the participants.

The need for additional technology

The additional technology usually supports the main technology to achieve the goal completely and perfectly. The additional technology could be hardware such as headsets or microphones or software such as applications.

Case_1 faced a problem to print her work directly from the tablet. As she did not mention anything about the need to print her work in Interview 1, this point was not considered when recommending the technology. However, providing additional hardware which connects the tablet with the printer solves the problem and saves time

> *"My brother brought me a cable which connects the device directly to the printer." (Case_1)*

For (Case_6), using the technology for a period of time showed the need of additional technology to achieve a better result. She noticed that using a microphone with a voice recognition application (Dragon Dictation) on her iPhone gave better results with minimal spelling mistakes.

> *"I just feel frustrated when the application wrongly writes the word. I found that the number of mistakes increases if I say more than two sentences. It is better with a microphone. A part of that it is good." (Case_6)*

The MTSF considers the additional technology in two ways. The first one is the need of additional technology to accommodate the abilities of the people with disabilities to send inputs and receive outputs from the technology such as Case_6. The second point is the need for additional technology to accommodate the surrounding environment in regards to issues such as privacy. However, sometimes the use of the technology for a period of time in the real environment can lead to identification of new needs or issues.

7.3.2 Pre and post-experience

This section presents some relationships that emerged between Interview 1 and Interview 2 while analysing and comparing data. These relationships include the relationship between a person's needs and preferences, knowledge and expectations, and finally motivation and type of tasks.

7.3.2.1 *Difficulty of transition from current to recommended technology*

There was a group of difficulties that made moving from the old way of doing a task to using a new technology hard for most people with disabilities.

The first difficulty is their fear of trying something new and how they can fit this new technology in their daily routine. This is clear in Case_2's response when he was asked about stopping use of a head stick (the old method) to access the computer

> *"I still have the desire to learn the computer, but because of age and living conditions I left that at the moment." (Case_2)*

Thus, because Case_2 is moving a lot between the hospital, home, and disability organizations he finds it difficult to try to fit and use something new in his daily life.

The second difficulty that makes moving from an old way of doing a task to using a new technology is being accustomed to the old way of doing the task. Even though the new technology mostly makes doing the task easier, saves time, and professionally achieves the goal it is still difficult for some participants to leave the old way and try something new.

Case_2 preferred using his iPhone to access Twitter more than using the tablet with track pad even though he faces many difficulties with the iPhone such as the small size of the screen and typing using his thump joint which takes long time to write.

> *"To be honest, accessing Twitter from my iPhone is easier because I use the Dragon Dictation app which makes the writing easier. Also Dragon has options to use the text as (tweet, SMS, Facebook status, and email). The device you gave me is as good as the Dragon on the iPhone. It's just that I don't have the time to set and use it frequently to get used to it and to get easier." (Case_2)*

Third difficulty is appreciating the old way of doing the task. The appreciation is not because the old way of doing the task achieves a better result than the new technology; it is because some participants feel that they have more control of the task. The following two cases are examples of that.

Even though Case_4 valued how the new technology (a tablet with a Bluetooth keyboard) assisted him to read books again, he still appreciated how reading hard copy books makes him remember information better.

> *"The device makes any information handy but reading from the text book makes the information more memorable." (Case_4)*

The same thing happened with Case_6 as she liked how the new technology makes typing easier and saves time. However, she appreciated having control of the writing task by making sure that the spelling is correct, while with the voice recognition software she has to revise the spelling after each sentence.

> *"Writing on the computer using speech to text software (Dragon Dictation) is more flexible and saves time. When I write by my hand I am sure the spelling of the word is correct but is more difficult than the software." (Case_6)*

The difficulties that face people with disabilities when moving from one way of doing the task to using a new technology include: difficulty of fitting the use of the new technology in the daily routine, the time invested in learning the old method, and appreciating some parts of the old method of doing the task.

Mostly people with disabilities face these difficulties at the beginning of using the new technology because they are still exploring the new technology and have not yet seen the advantages of the new technology. Sometimes, using the new technology does not achieve 100% of the participant's goal, however comparing the advantages and disadvantages of the old method of doing the task and using the new technology makes the choice easier.

7.3.2.2 *Conflict between needs and preferences*

As the research participants are people with physical disabilities, their needs regarding interaction methods are taking higher priority over the preferences regarding the design of the technology. The interaction methods include the input and output channels. The participants should be able to send input and receive output easily and effectively, considering their physical disabilities. Then, the preferences regarding the design of the technology come in the next place. Most of the participants' preferences focus on not attracting attention while using the technology.

For Case_2 the need for a big screen is to overcome the difficulty of seeing the texts on the iPhone screen and not being able to bring the iPhone closer to him as he cannot bend his arm. His preference is using a technology that can travel with him to work, hospital, and conferences. When holding the tablet on his wheelchair was recommended for him he refused that because he thought this would attract attention to his disability

> *"Even if I can take it with me everywhere, it is still big and attracts the attention of others and I don't want that" (Case_2)*

Even though the tablet is considered a mainstream technology and he has used a wheelchair already, he still thinks the 10" screen of the tablet attracts attention to his disability.

Case_3 needs another input option to overcome the difficulty of using the touch screen of the smart phones. The solution was a smart phone with a Bluetooth keyboard. The solution satisfied the need of having a big screen and a keyboard with a distance buttons to use at home on the table of the wheelchair. However, Case_3 preferred to go back to the keyboard that attached to the smart phone to save a place for other activities on the wheelchair's table and be able to use it everywhere.

> *"Size: it is good but not for making calls and for using everywhere. Even if I put it on my wheelchair table it takes up a big space so I can't do anything else like eating. Weight: reasonable but I still can't hold it." (Case_3)*

The reason behind the conflict in Case_3's situation is that she changed her mind about the technology requirements and the environment where she wanted to use the technology. During Interview 1 Case_3 mentioned that she wants a technology that overcomes the small screen drawback in her old mobile phone, with bigger keyboard buttons to use inside her home on the wheelchair table. After having the technology she said the technology is big, taking space, and hard to use outdoors. This situation can be solved by conducting the first interview again or further follow-up.

Another conflict in Case_3's situation is between her need of a technology that overcomes the difficulty of using the Facebook and Twitter on the old phone and the amount of the time that she spends on learning the technology. Even though she first asked for a technology that enables her to make calls, send messages, and use Facebook and Twitter, she later complained that the technology has more than she needs

> *"The technology is good. I give it 70% but it takes a lot of my time because I spend more time on Facebook and Twitter. I just want a device that enables me to make call and send messages but this device has everything. It is just like a laptop" (Case_3)*

The conflict in this case is related to the change in the technology requirements. The conflict is because Case_3 does not order her priorities of using the technology. In the first interview she gave making calls and sending messages higher priority than using Facebook and Twitter. Balancing the use of the technology to achieve the main task and get benefits from the other technology features is up to the user.

Case_1 represents a good example of the conflict between the needs and the preferences of the technology design. She gave the design of the technology higher priority than meeting her needs. The reason again is not attracting attention

> *"To be honest, I will not be lying, I prefer technology that meets 60% of my needs and looks normal or beautiful more than technology that meets 100% of my needs and looks specifically designed for people with disabilities." (Case_1)*

The MTSF has couple of steps to try to avoid any conflicts in the use of the recommended technology. First, when the assessment is completed in the first interview, detailed information is gathered about person's abilities and technology requirements. Second, the decision tool tries to make a balance between the person's abilities, needs, and technology requirements to recommend an appropriate technology solution.

In addition to the assessment in the first interview, the technology solutions that are adopted by the MTSF are selected from the mainstream technologies range. These solutions meet many needs of people with disabilities where the needs are related to technology design. The mainstream technologies satisfy the needs of people with disabilities by enabling them to avoid being the focus of other people's attention. The mainstream technologies are accepted and even people without disabilities use them.

7.3.2.3 *Relationship between awareness-knowledge and expectations*

The person's expectation refers to thoughts and perceptions, which the person has before using mainstream technologies. The expectations could be related to technology design, a person's view about his or her abilities to use the technology, or the circumstances which support or prevent the use of the technology. The awareness-knowledge refers to the information which the people with disabilities have about the technologies and what the technologies can offer for them. Meeting the participant's expectations is a key influence on the success of both the selection process and encouragement of participants to use the technology. When the person with disability has a high awareness-knowledge about the technologies s/he can expect what the technology solution would look like.

Case_2 has high awareness-knowledge about technologies from his working in a disability organization and attending disability conferences.

He has knowledge about different ways of controlling the technologies to overcome the physical disability.

> *"I know people who control their electric wheelchairs with their heads. I know a person and he is a doctor. He drives the electric wheelchair with his chin."*

He mentioned how Stephen Hawking uses technologies to communicate with others.

> *"I know many people with disabilities who activate technology by voice or eyes and I knew a British man who communicates with the world by his voice using a computer" (Case_2)*

He also witnessed many experiments of accessing technologies by people with disabilities.

> *"I knew some people with disabilities who added many attractive things to help them to use technology such as a special hat" (Case_2)*

Case_2 got a tablet with a track pad. He has experience in trying to use head stick technology to access a computer.

The high awareness-knowledge explains his response as regards the position of the recommended technology from his expectation.

> *"Yes, it is like what I expected" (Case_2)*

The high awareness-knowledge gave him a good view about what the recommended technology would look like which placed the recommended technology in his expectation range.

On the other hand, Case_4 had never used any technology and he had low awareness-knowledge which was obvious when he wished to have a magnifying lens to enlarge the book text. He already had glasses however he still could not see the book text

> *"I also love reading so much, but nowadays I can't because the text is too small for me to see. I wish I have a magnifying lens" (Case_4)*

The recommended technology for Case_4 was a tablet with a library application and a Bluetooth keyboard. The library of his favourite books on the tablet was controlled by the Bluetooth keyboard. He was able to read books for the first time in a long time. When he was asked how the recommended technology met his expectations, he responded:

> *"It is more than I expected." (Case_4)*

For Case_1 the situation was slightly different because her awareness-Knowledge was low about what technology could offer for her. She had some information about technology from TV shows

> *"I saw a program where the person controls a device by his eyes and he can flip pages and read a book. I like it." (Case_1)*

However, she has an experience with an assistive technology, which was attached to her hand to support it. The assistive technology helped her do many tasks such as eating, typing on the computer, and handling things such as books. Thus, her expectation was going around this type of assistive technology. The recommended technology for her was a tablet with a touch sensitive keyboard which is far from her expectation

> *"It is more than I expected. To be honest, I expected something to attach to my hand but it does not. The device looks great." (Case_1)*

The common thing between Case_4 and Case_1 is that the both participants have low awareness-Knowledge which can be linked to their low expectations. In these cases the recommended mainstream technologies are given a better chance to prove the effectiveness and meet their expectations.

Mentioning voice recognition as an assistive technology by Case_6 tells that she has a good idea about what the technology can offer for her.

> *"If I can type without using my hands at all that will be great like using voice recognition" (Case_6)*

Even though she knows exactly what she wants, when she tried the software by herself she valued the experience.

> *"It exceeds all my expectations." (Case_6)*

Case_6 is an example of how the use of the technology in the real environment of the people with disabilities makes a difference to their impression of the technology. Thus, giving the person with disability an opportunity to try the technology in a real environment helps the person to explore the features of the technology that s/he really needs and measure the actual benefits.

The awareness-knowledge of Case_3 formed from her journey to find a new smart phone with buttons, instead of the blackberry, as she cannot use the touch screen.

> *"I have searched for a long time for a mobile phone which has big buttons." (Case_3)*

She was using a Blackberry which was good to some extent. However, the buttons were small and close to each other. Thus, she kept looking for a mobile with big and distant buttons

> *"My brother went to Britain and I asked him to bring a device for me. He said: nothing but touch devices." (Case_3)*

The solution was a smart phone with a big screen and a Bluetooth keyboard with big and distant buttons. It overcomes the difficulty of using the small keyboards of the Blackberry however it is not considered an unexpected solution for her.

> *"The technology comes in my expectations range." (Case_3)*

The participant's view toward the meeting of the recommended technologies of their expectations divided into two groups. First group sees that the recommended mainstream technologies are within the range of their expectations. The second group sees that the recommended mainstream technologies are above the expectations. However, in terms of the relationship between the awareness-knowledge of the participants as regards technologies and their expectation, for most of the participants who have high levels of awareness-knowledge, the recommended technologies come in the range of their expectations. On the other hand, participants who have a low level of awareness-knowledge show that the recommended technologies exceed their expectations. The MTSF considers meeting the participants' expectations in Interview 2. Asking the participants about how the recommended mainstream technologies meet their expectations in the second interview is an important step to measure the level of acceptance which has a crucial influence on the use of the technologies.

7.3.2.4 *Relationship between motivation and the frequent of use*

The motivation is the hidden secret behind the use of the technologies. A strong motivation to achieve specific tasks will encourage the person with disability to use the recommended technology and also to improve his/her performance. Achieving the task with minimal difficulties requires continue using the technology in a real environment for a reasonable time. Thus, the person with disability can explore the technology and learn how to use it properly.

Case_2 has a disability as a result of a car accident more than 20 years ago. He mentioned a motivation to learn how to use the computer for writing and information searching, however he mentioned many obstacles which prevented him from doing that. In addition, a few years ago he started using an electric wheelchair.

> *"I still have the desire to learn the computer, but because of age and living conditions I left that at the moment. Just a while ago I learnt to use the electric wheelchair in a simple way." (Case_2)*

Having a disability for more than 20 years and still having excuses for postponing use of the technology shows how low the motivation of Case_2 to use technologies is in general. This explains the number of times that the recommended technology has been used by Case_2, which was a few times in two weeks.

In contrast to Case_2, Case_4 is highly motivated by being able to read books again. He was still reading hard copy books recently. While he prefers that over the electronic versions, he has accepted the new way of reading.

> *"I also love reading so much but nowadays I can't because the text is too small for me to see. I miss reading books so much" (Case_4)*

He prefers the hard copy books because he can better understand and remember the text printed inside a book than an electronic version. Case_4 cannot hold the books or even flip pages, which is another strong reason that encourages him to use technology. For reasons related to the availability of the technology, Case_4 used the recommended technology for three days. Even though the duration of the technology use was short he demonstrated a strong motivation to use the technology as much as he could to read again by using the tablet more than once every day for three days.

Like Case_4, Case_6 is highly motivated by writing stories. She likes writing books and novels but because she cannot write on the computer for a long time using one finger she chose to write short stories as she stated

> *"I like writing short stories just because I feel tired of writing, but if I found a technology that helps me to write maybe I will write novels as well. I have already started writing my first book but it takes so long to finish because of the difficulty of writing" (Case_6)*

The recommended technology for Case_6 was a voice recognition application. She found the application useful for many things other than the writing of the stories which explains why she used the technology most of the day for one week. She used the application on her smart phone which allowed her to document her thoughts, stories, and messages almost everywhere.

For Case_3 the situation is different. Her motivation behind using the technology was using smart phones with touch screens easily and comfortably. The recommended technology for Case_3 was a smart phone with big screen and touch screen and a Bluetooth keyboard.

However, even though she stated that the recommended technology overcame the difficulties of the old technology by 70%, she was still not satisfied

> *"It overcomes the size of the keyboard buttons and the screen by 70% as I said, however I aspire to have a device that helps me to reach 100%" (Case_3)*

Her motivation to use the recommended technology is low at a rate of about once a day because she keeps admiring other technologies' features. Case_3 tries to overcome 100% of the difficulties and that is what makes her motivation levels change over time.

Drawing clear lines of the relationship between motivation and the frequent of use of the technology is much easier than the relationship between awareness-knowledge and expectations. However, to make the relationship between motivation and the frequent of use of the technology easy to understand, another factor should be considered which is the task.

If the task is something that the person used to do before having the disability even in different way, the motivation to be able to continue doing that task will be higher than the motivation to do incidental tasks after having the disability.

To make that clear, compare Case_2 as an example of motivation to do an incidental task with Case_4 as an example of motivation to do a usual task. Case_2 decided to search, read, and write after having the disability for many years, whereas reading books is part of Case_4's daily routine even before having the disability.

7.4 Discussion

This section presents the discussion of the changes to the MTSF which were made based on the analysis of the responses of the participants. These responses were represented in the findings section. The changes were made to overcome the disadvantages and difficulties faced by the participants while using the recommended mainstream technologies. The discussion also discusses the relationships that emerged between themes. The relationships were presented in the findings section with quoted evidence from the interviews. However, all changes are discussed in light of the literature, theoretical framework, and the practical implication. The purpose of these changes is to improve the MTSF to provide better mainstream technology solutions for people with physical disabilities.

Table **7.2** shows the actions that had been taken to develop the second phase of the MTSF. The second phase of the development includes changes in Interview 1 questions by adding more questions or changing the structures of others. The following sections discuss the changes.

Table 7.2. The changes to $MTSF_1$ to develop $MTSF_2$ and the reasons for these changes

	Changes		
	$MTSF_1$ Interview 1 questions	**$MTSF_2$ Interview 1 questions**	**Reasons**
Ch1	Can you suggest at least THREE activities for which you wish you had technology? I wish there is a technology that helps me to do:	In addition to the previous question the following question was added: Can you break the task into subtasks by dividing the task into steps? Step1:……… Step2:………. . . . Step N:……….	To be aware of the additional technologies that enhance independence through the different steps of the tasks.
Ch2	*No question asked*	Is this task something that you used to do before having the disability (in case of acquiring disability at a later stage of life)?	Knowing if the task is incidental or usual gives an indicator of the motivation level of the participant.
Ch3	*No question asked*	Is your disability from birth or a later stage of your life?	Again, gives an indicator of the motivation level of the participant.
Ch4	Where do you intend to use the technology? (Indoor, outdoor)	Describe the environment where you intend to use the technology?	Gives more details about the environmental factors which could affect the use of the technology.
Ch5	*No question asked*	How did the use of the recommended technology affect your self-identity?	Knowing the relationship between the use of the technology and the self-identity can lead to adjusting the technology preferences to promote positive self-identity.

7.4.1 Decompose the task to subtasks

The main purpose of asking the participants about the task that they want to achieve using the technologies is detecting the task carefully. This is the first key to solving the appropriate technology mystery. This meaning was mentioned widely in the literature by using different terms such as goal (Copley & Ziviani 2005) and activity (Cook et al. 2010). Regardless of the different terms of tasks in the literature, all of them agree that detecting the task accurately and in the early stage of the assessment process of selecting the appropriate technology is a crucial step. Copley and Ziviani (2005) mentioned the concept of task analysis as a part of the plan that should be made for the students with disabilities in their schools and how the task analysis can assist in determining the abilities of the person and the needed technologies. Furthermore, the theoretical framework of the research (activity theory) addressed the goal (task) as one of its six major concepts. The goal in the activity theory is a result of the interaction between the person and the tool. Thus, the task was given special consideration in the MTSF by asking the participants about the task at the beginning of Interview 1 and analysing how the task was achieved previously. Nevertheless, some findings indicated that is not enough to detect the task clearly and accurately. Some participants stated that they are still dependent on someone else in some parts of the task. In addition, other participants indicated that they needed additional parts (such as a cable to connect the tablet with the printer) to the recommended one to accomplish the task. The analysis of these findings leads to the need to identify the task in more accurate way which guarantees that the participants are more independent and obtained the recommended technology as a complete system (unit) to achieve their goals. Thus, the technique of the task analysis (Shepherd 1989) was used to decompose the task to subtasks. The technique was used in Interview 1 by adding one more question in the task section (see Table **7.2**, Row 'Ch1'). Two objectives were satisfied by this addition. The first objective is to achieve more independence by going through the subtasks with the participants and detecting where the participants still need help and how they can be assisted to achieve the level of independence they desire using the recommended technologies. The second objective is to make a decision regarding each subtask: whether it can be completed independently with the recommended technology or whether additional technologies or parts are needed.

7.4.2 Obtain more details about the environmental factors

The environment where the participants intend to use the recommended technology is considered an important factor that directly affects the use of the technology. The environment includes light, sounds, physical barriers, and other people. First in Interview 1 the participants were asked a question about where they intend to use the technology? However, other detailed information about that environment is left to the imagination of the interviewer. This enables the gathering of important information for predicting. The responses of the participants to the environment question articulated that just knowing where the participants intend to use the recommended technology is not enough. Most literature (Goette 1998; Wessels et al. 2003; Copley & Ziviani 2005; Scherer & Glueckauf 2005; Seymour 2005; De Jonge & Rodger 2006; Scherer et al. 2007) strongly mentioned the importance of knowing complete information about the environment such as physical barriers, the background noise, the light and the people around the person who uses the assistive technology. Most of the literature that indicated the factors affecting the use of the technology covers assistive technologies. This research is specifically concerned about mainstream technology. The environmental barriers such as light and sound did not gain important consideration. One reason is the researcher belief that the mainstream technology is obviously designed to be used mostly everywhere which make it more adjustable to accommodate diverse environments. The other reason is that use of the technology by the participants in the real environment is the best way to know the environmental requirements. However, this belief is not right all the time, evidenced by the need of some participants for additional technology to overcome some environmental barriers, for example the need of a headset with a microphone to use voice recognition software in a noisy environment such as a university. As a result the question is changed to ask the participants to describe the environment where they intend to use the recommended technology (see Table **7.2**, Row 'Ch4') which gives a clearer idea about the environmental factors and any barriers that could prevent them from perfectly using the technology. The description of the environment by the participants can help to make a decision about the additional technology or adjustments that could be needed to overcome some barriers. The activity theory which is the theoretical framework of the research is a high level conceptual framework. So activity theory did not address the environment components clearly. However, the activity theory considers the community as one of its six concepts, allowing the researcher to redefine the community concept to cover the environment and its components such as: physical environment and family.

7.4.3 Intersection of motivation, task and disability

The findings analysis showed an intersection between the level of the motivation of the participants, the task, and the disability. The first aim is to study the relationship between the motivation of the participants and the frequency of the technology use. Obviously, the logic stated that if the person has high motivation to achieve a goal, s/he will use the technology more often and vice versa see Table **7.3**.

Table 7.3. The relationships between motivation, task, and disability

Participant	Motivation	Frequent of technology use	Task	Disability
Case_2	Low	Low	Incidental	Late in life
Case_3	Low	Low	Incidental	Late in life
Case_4	High	High	Usual	Late in life
Case_6	High	High	-	From birth

However, another interesting relationship emerged while analysing the previous relationship. It has been observed that the motivation was low for the participants who have disability in a late stage of their life such as Case_2 and Case_3. On the other hand, Case_4 also acquired disability in a late stage of his life, however his motivation was high (see the highlighted row in Table **7.3**). Consequently, a search began for the other factors that caused this difference. The analysis of Case_4's Interview 1 showed that he did not recently acquire a high motivation to read books. He also used to read books every day before having the disability, so this task (reading books) is not incidental in his life after having the disability. This is not the case for Case_2 and Case_3. Case_2 desired the ability to use the computer after having the disability, whereas he had not used it before. Similarly, Case_3 wanted to be able to use smart phones with touch screens and she had never used one. Understanding the factors which affect the motivation levels assists in maintaining a high level of motivation. This leads to use of technologies more often to achieve the desired goals. The literature did not addressed the motivation concept directly, however some literature such as (Wessels et al. 2003) and (Scherer et al. 2007) talked about how the level of the technology acceptance and use can be affected by the time in life when the person acquires the disability. Wessels et al. (2003) divided the people with disabilities in this context into three categories:

Table 7.4. The relationship between the disability and the level of acceptance (adapted from Wessels et al. 2003)

Disability	Acceptance/ use
From birth	High rate of acceptance
Acquired disabilities suddenly	Difficulty in coping
Developed gradually	High rate of rejecting

The relationship between the disability and the level of acceptance in Table **7.4** supports the observed relationship between the motivation, disability, and task. As shown in Table **7.4** the people who have their disabilities from birth have a high rate of acceptance, which explained the high level of motivation in Table **7.3**. In contrast, Table **7.4** shows that people who have disabilities in later stages of their lives, whether suddenly or gradually, found it difficult to cope with the technology or even reject it completely, illustrating the low level of the motivation for the same group in Table **7.3**. Riemer-Reiss and Wacker (2000) mentioned a practical way to improve the level of acceptance and thus a high level of motivation. The way is to involve the person with disability in the selection process of the technology, so the person feels that his/her opinion is considered and that s/he has control of the alternatives available.

As the theoretical framework of this research (activity theory) is a high level conceptual framework there is no mention of motivation, as a relationship controls other concepts. The motivation could be presented in the activity theory which was modified to be applicable in the disability context.

The observed relationship between the motivation, disability, and task affected the MTSF and improved it to consider the type of the disability and the task which helps detect the level of the motivation of the participants before using the technology. Two questions were added to the MTSF to address the motivation issue. The first question was added to the task section in Interview 1 to cover the type of the task (see Table **7.2**, Row ‘Ch2’). The purpose of the question is to ascertain the level of the person’s motivation by asking whether the task was incidental or done before acquiring the disability. The second question was added to the personal information section to cover the type of the disability (see Table **7.2**, Row ‘Ch3’). The purpose of the question is to discover whether the disability was from birth or acquired at a later stage of life.

Predicting the level of the motivation at an early stage of the selection process leads to considering more involvement of the person with the disability. For example, after selecting the technology we can present the solution for the participants and go through the requirements again to make sure that the collected data is correctly understood and to give the participant the feeling that s/he has control on the choice.

7.4.4 Reasons of conflict between needs and preferences

The findings analysis of the main cases showed that there is a conflict between the participants' needs and their preferences. Mainly, the needs cover all facilitators which assist the people with disabilities to achieve their goals or tasks easily and effectively. Facilitators include the technology features of the main solution such as big screen and keyboard with big buttons as well as additional hardware technologies such as headsets and software technologies such as library applications. The preferences include issues that do not affect achievement of the main goal, although they are related to the external design of the recommended technology. The reason of this conflict for most of participants is their desire not to attract attention. The interesting fact is that all participants use wheelchairs and they still think that using a tablet with 10" screen attracts attention to their disabilities. Given that all participants participated in the research and they knew that a technology will be provided to them to assist them achieve their goals by doing tasks that they are not able to do without the technology. Furthermore, all solutions will be selected from the mainstream technologies. However, question still not answered is why Case_2 stated that he will not continue using the recommended technology. Despite this, he said that the technology met his needs. To understand the reasons for refusing to continue using the recommended technology, the Interview 1 of Case_2 was revised to detect any needs that are not considered while searching for the solution. A number of interesting issues were founded. First, he emphasised that even though he is a person with disability, he can prove and show that he still uses his mind effectively to think, communicate, and share ideas. Second, Case_2 was similar to Case_1 in that they do not want to use technologies that attract attention to their disabilities. Third, both Case_2 and Case_1 expected that the recommended technologies would not be normal which means they would use technologies that are not in everyone's hands. For Case_2, the solution was a tablet with a track pad; for Case_1 the solution was a tablet with a sensitive touch keyboard. Even though both recommended technologies were mainstream technologies and both participants stated that the technologies met their needs, Case_2 mentioned that he would not continue using the technology, while Case_1 was very thankful and illustrated that the technology was a gift for her. Thus, what is the difference between Case_2 and Case_1 that leads to different results? Looking back to the three interesting issues that were found in Case_2's Interview 1, the first issue emphasises his ability to think and share ideas leading to the difference between the two cases. A relationship can be shaped between the refusing of continuing use of the technology and the view of self, to explain the conflict between needs and preferences. The relationship between the internalised view of self and the use of the assistive technology is mentioned in the literature. Pape et al. (2002) and Gooberman-Hill and Ebrahim (2007) stated that the people with disabilities might stop using the assistive technology if it does not meet their own view of themselves or promotes negative self-identity. Case_2 felt that using the technology conflicts with his desire to prove that he still can think properly and express himself.

The internalised view of self was not mentioned in the theoretical framework (the activity theory) however this factor can be included under the subject concept.

The emerged relationship between self-identity and the use of the technology improves the MTSF by including one question about this issue to Interview 1. The question is how the use of the technology affects self-identity? This was added to Interview 1 (see Table **7.2**, Row ‘Ch5’). Understanding the relationship between the use of the technology and self-identity leads to adjusting the technology preferences to promote positive self-identity. Thus, the likelihood of continuing to use the technology will increase.

7.4.5 Affecting of awareness-knowledge on expectation

Meeting the expectations of the people with disabilities increases the likelihood of continuing to use the technology. For this reason, analysing the participants’ responses has been done to find the factors that affect the expectations of the participants as regards the technologies. The findings analysis showed that there is a relationship between the level of awareness and the expectations. If the awareness of the person is high, mostly the recommended technology comes into his/her expectations range. On the other hand, if the awareness of the person is low, mostly the recommended technology exceeds his/her expectations.

Even though the findings showed a relationship between the awareness and the expectations, this relationship is not supported by sufficient evidence. These findings are in line with the literature of expectations. The literature showed that the person’s expectations are important in the selection process, however none mentioned a relationship between the awareness and the expectations of the person with disability. Some literature stated that the expectations of the people with disabilities regarding technologies are shaped by the social values (Scherer et al. 2007). Another study showed that the expectations of the people with disabilities regarding technologies indicates the successfulness of the matching process (Seymour 2005). Because the mainstream technologies are socially accepted, the social values are excluded from the research scope. As a result, regardless of the factors that affect the expectations of the people with disabilities, the most important point in this context is to acknowledge these expectations and provide a technology solution which meets these expectations as much as possible.

The theoretical framework (activity theory) does not mention the person's expectation as a concept. However, the activity theory can be amended to consider the person's expectation by adding it as an outcome of the task concept.

As the findings analysis shows insufficient evidences for the relationship between the awareness and the expectations, no changes have been applied to the MTSF to reflect this relationship. However, the importance of measuring the level of the expectations as a strong indicator of the success matching process is still considered in Interview 2. Interview 2 has a question about how the recommended technology meets the expectation of the participants. This allows prediction of the effectiveness of the recommended technology.

7.5 Implications

The findings analysis and discussion improve the theoretical framework (activity theory) to be applicable in the disability context. The improvements are a response to the disadvantages that face the participants while using the technology, to increase the quality of the technology solutions. In addition, other improvements are a reflection of some emerged relationships between concepts. The improvements include adding new factors and relationships between concepts to the theoretical frameworks. Motivation, self-identity, and expectations are examples of new factors which are added. The relationship between motivation, task, disability, and the relationship between preferences and self-identity emerge to explain the connections between the existing and new factors. See $MTSF_2$ which presents all the refinements in this chapter after analysing the main cases responses.

$MTSF_2$ (Amended version after Phase 2)

Interview (1): Assessment of needs and abilities

Name ______________________________ Code ______________________________

Age ______________________________ Contact details ______________________

Date of interview (1) __________________

Type of disability ____

Brief description ____

____

____

1. Tasks (activities)

Can you suggest at least THREE activities for which you wish you had technology?

I wish there is a technology that helps me do:

____

____

____

Ignore the following question in case the participant answered question (1)

____

What are the kinds of activities that family members or carers do for you?

____

____

____

Choose one task from question (1) or (2) to complete the rest of the interview.

The chosen task is: ____

Can you break the task to subtasks by dividing the task into steps?

Step1: _______________

Step2: _______________

.
.
.

Step N: ______________

Is this task something that you used to do before having the disability (in case of having disability in a later stage of the life)?

____

____

Analysis of current situation:

How do you currently accomplish the task?

____

____

____

What are the advantages of the currently used method?

____

____

____

What are the disadvantages of the currently used method?

____

____

____

Ask the following question in case the participant mentioned non-technological method in question (1)

Did you ever use any technology to help you do the task?

____

____

____

Have you had any problems with technology that supported you in the past?

____

____

____

2. Personal information

Abilities

Is your disability from birth or a later stage of your life?

____

____

How do you rate and describe your ability in regards to the following interaction capabilities?

*Interaction capabilities scale: 0(None), 1(Poor), 2(Fair), 3(Good), 4(very Good), 5(excellent).

Capabilities	**Rate**	**Description**
Vision	……...	……………………………….………
Hearing	……...	…………………………………
Somatic (the ability to sense touch)	……...	…………………………………
Audio (speech)	……...	…………………………………
Head control	……...	…………………………………
Shoulder control	……...	…………………………………
Arm control	……...	…………………………………
Elbow control	……...	…………………………………
Hand control	……...	…………………………………
Finger control	……...	…………………………………
Knee control	……...	…………………………………
Foot control	……...	…………………………………

Do you prefer specific methods to interact with the technology?

How does the use of the technology affect your self-identity?

3. **Environment**

Describe the environment where you intend to use the technology?

How do you want to interact with technology (sitting, on the go)?

How long/often do you expect to use the technology?

How do the attitudes of people around you affect the use of the technology?

Do you prefer the technology to be visible or inconspicuous?

____

Do you have any special requirements in regards of?

Technology size ____

Technology weight ____

Technology's features ____

Other ____

____

would you like to add anything?

____

____

____

Interview (2): Evaluation (step 4)

Name ______________________________ Code _______________________________

Technology ____

Date of evaluation _____________________________________

How long had the technology ____________________________

Number of times using technology ________________________

1. The goal (needs)

What was your goal?

____

Did the technology help you achieve your goal?

____

____

____

How effective your technology is (the degree to which the technology meets your needs)?

____

____

____

How does the technology overcome the previous difficulties?

____

____

____

Do you still need help from family members or carers to do any part of the task?

How do you compare the previous method of doing the task and using the technology to do the same task?

Were there other things that you used the technology for?

2. The technology

What was the technology that you used?

What task were you doing using the technology?

What are the advantages of the technology?

How easy was it to use your technology?

How comfortable was your technology (physically and emotionally)?

Were there any difficulties in using the technology?

How does the use of the technology meet your expectations?

How satisfied are you with:

- Physical features (e.g. size, weight)

- External design (e.g. colour, visibility)

- Technical features (e.g. battery, screen brightness)

____

____

- Privacy (e.g. sound)

____

____

3. The environment

Did you use the technology in the environment you intended? If not why?

____

____

____

How did the technology overcome the environmental barriers (light, sound)?

____

____

____

How do the opinions of people around you affect your continued use of the technology?

____

____

____

Would you continue use the technology in the future? Why?

____

____

____

____

7.6 Conclusion

In this chapter findings from analysing the main cases were presented. Analysing the main cases started by translating the participants' responses to Interview 1 and Interview 2 from Arabic to English. Then, Interview 1 and Interview 2 were coded by using Nvivo software. The findings divide into two main themes. The first theme is the technology which includes the value and the difficulties of the currently used technologies and the value and the difficulties of the recommended technologies. The purpose of the first theme is to compare the situation of the participants in doing the different tasks before and after using the mainstream technologies. The second theme in the findings is the experience of the participants before and after using the mainstream technologies. Coding the experience of the participants showed significant relationships between the number of subthemes such as the relationship between motivation, task, and disability and the relationship between preferences and self-identity. These main themes, subthemes, and the relationships between them represented interesting findings which were used to refine the $MTSF_1$. $MTSF_2$ presents all refinements which emerge in this chapter. The next chapter presents the findings and discussion of evaluating the $MTSF_2$ by rehabilitation and occupational therapists.

Chapter 8

Rehabilitation and Occupational Therapists' Evaluation of the MTSF

8.1 Introduction

This chapter presents therapists' evaluation of the MTSF. First, it states the purpose of conducting the evaluation and the analysis technique. Second, it discusses the method used, including how the participants in the evaluation were recruited, the description of the participants, and how the evaluation was conducted. Finally, the findings and discussion are presented under two consecutive sections: detailed evaluation and overall evaluation.

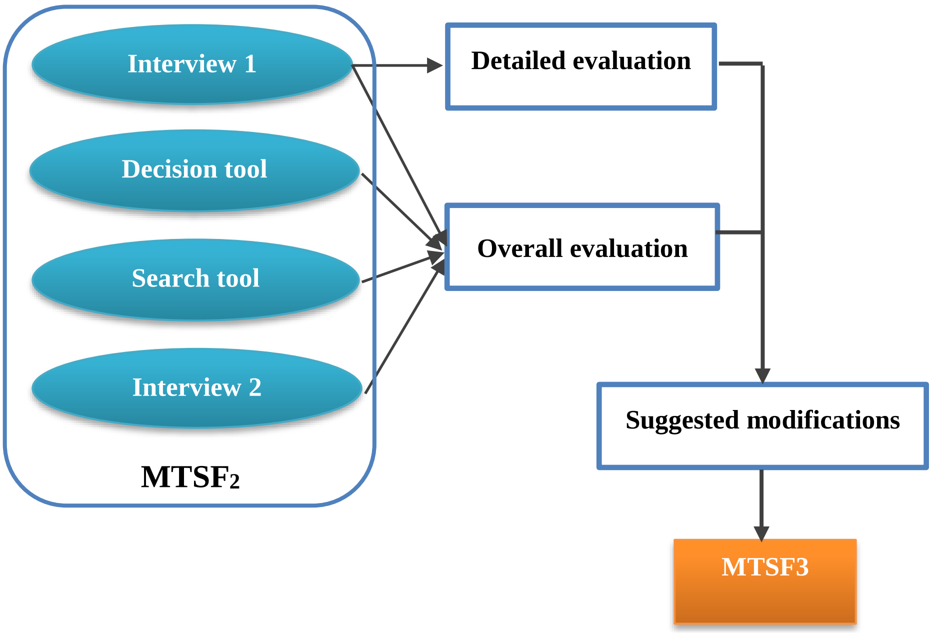

Figure 8.1. Process of the evaluation tasks of the Mainstream Technology Selection Framework (MTSF)

The purpose of the evaluation is to ensure the validity of the MTSF from the rehabilitation and occupational therapists' points of view and to ensure that MTSF is applicable in practice. In order to evaluate the MTSF we conducted two separate evaluation tasks: detailed evaluation of the first tool (Interview 1) of the MTSF and overall evaluation of the entire MTSF. To make sure that the MTSF is valid we need to ensure that the concepts of the MTSF are well defined and founded (detailed evaluation). In addition, ensuring validity includes examining the comprehensiveness and effectiveness of the MTSF at selecting the appropriate mainstream technologies for people with physical disabilities (overall evaluation). It can be observed that the detailed evaluation is deeper and more elaborate than the overall evaluation. The reason for this was that the detailed evaluation and overall evaluation were conducted on different levels. The detailed evaluation focused on the language of the questions of Interview 1. The effectiveness of each question was based on obtaining the required information. The overall evaluation focused on the comprehensiveness of the MTSF to ensure that all the important factors were covered and the effectiveness of the MTSF to ensure that it can provide a practical framework for use in occupational and rehabilitation therapy applications. In addition, the detailed evaluation was conducted by a team of three rehabilitation therapists, whereas the overall detailed was conducted by one occupational therapist. The next sections describe each task of the evaluation.

8.1.1 Detailed evaluation of the first tool of the MTSF

In the detailed evaluation, a team of three rehabilitation therapists provided detailed feedback regarding questions of Interview 1 (the first tool of the MTSF). Thus, because they are from the same hospital and they reviewed the questions of Interview 1 together, their comments were combined together and referred to them as the "Rehab_therapists team". The output of this evaluation task comprises suggested modifications if the MTSF is used in rehabilitation applications (see Figure **8.1**). The decision to conduct a detailed evaluation of Interview 1 came from recognizing the importance of Interview 1, the tool to collect the person's requirements regarding goal, environment, and the technology. Furthermore, the rest of the MTSF tools obtain the needed data from Interview 1. Thus, we can say Interview 1 is the foundation of the MTSF. After reviewing and analysing the comments from the Rehab_therapists team the suggested modifications were incorporated into the revised Interview 1.

8.1.2 Overall evaluation

In the overall evaluation, an occupational therapist was asked to evaluate the entire MTSF including all four tools: Interview 1, decision tool, search tool and Interview 2 (see Figure

8.1). The overall evaluation focuses on the effectiveness and comprehensiveness of the MTSF. The occupational therapist conducts the overall evaluation by reviewing the MTSF then answering an evaluation questionnaire. The purpose of the overall evaluation was to ensure that the MTSF covers every important factor that affects the selection of the appropriate technology for people with physical disabilities and the ability of the MTSF to conduct an effective selection process in practice.

8.2 Method

Although a number of professions select technologies for people with disabilities, there is a lack of profession that is specifically specialized and trained in technology matching. Often the people doing this work are not technology specialists (Institute of Medicine (US) Committee on Disability in America 2007). Due to the absence of a recognized specialty to carry out the selection of appropriate technology for people with disability, any therapist having a role in the process of matching a person with technology was considered a representative therapist. Mostly the rehabilitation therapists or the occupational therapists are the therapists who carry out this task. Thus, rehabilitation and occupational therapists were recruited through a rehabilitation hospital and medical centre. The following is a description of the therapists who participated in the evaluation.

8.2.1 Description of the participants

Table **8.1** shows information about the therapists regarding their role and type of experience, how long they have been in this role, and the tool(s) already used to achieve their goal.

Table 8.1. Details of the therapists who participated in evaluation tasks

	Type of expertise	Duration of expertise	Tools used by therapist
Rehab_therapists	Physiatrist and rehabilitation consultations	10-20 years	Awareness questionnaire for patient, family and clinician
Occupational_therapist	Occupational therapist specialised in hand and burn injuries	16 years	Functional abilities assessment. Upper limbs strength assessment. Mental health assessment.

Rehab_therapists team has 10-20 years of experience in consultant physiatrics and rehabilitation medicine. Its members are from Belgium and work at a humanitarian city in Saudi Arabia. They worked as a multidisciplinary rehabilitation team specialist in developing the brain injury speciality Rehabilitation Pathway. As a result of their speciality in brain injuries they have been using the awareness questionnaire Rehabilitation Measures Database (2010) which is a tool to measure the level of the self-awareness of the patient after a traumatic brain injury.

Occupational_therapist has 16 years of experience in occupational therapy. She is from Egypt and works at a hospital in Saudi Arabia. She is a specialist in the rehabilitation of patients with hand and burn injuries to improve their independence in performing daily life activities. She focuses on basic activities such as wearing clothes, eating, taking a shower, and using different devices around them. In order to assist the patients to be more independent, she provides them with assistive technologies.

8.2.2 Procedures of conducting the evaluation tasks

The two tasks of evaluation were conducted in parallel. In terms of the detailed evaluation, an invitation to participate along with Interview 1 (the first tool of the MTSF), the explanatory statement, the consent form were sent to the Rehab_therapists team. The Rehab_therapists team was asked to comment on each question of Interview 1.

In terms of the overall evaluation, a booklet was created including a description of the MTSF objective, a presentation of MTSF tools, instructions of how to use the MTSF, and finally the evaluation questionnaire. Then, the booklet with the explanatory statement and the consent form along with an invitation to participate were sent to Occupational_therapist. Occupational_therapist was asked to answer the evaluation questionnaire after reviewing the booklet. Finally, a telephone interview was conducted with Occupational_therapist to discuss her answers to the questionnaire questions.

The contact with the therapists was undertaken online. Next, the researcher analysed the responses of the therapists and the suggested modifications were integrated into the MTSF. The next section presents the findings and discussion of the evaluation tasks conducted by the therapists.

8.3 Findings analysis and discussion

Analysis and discussion of the comments of the therapists in detailed and overall evaluation tasks are presented in the next sections.

8.3.1 Detailed evaluation of the first tool by the Rehab_therapists team

The detailed evaluation includes analysis and discussion of the comments of the Rehab_therapists team on the questions of Interview 1. The comments focused on four areas: personal information, the type of the task, subtasks accompanying the task, and assessing the functional capabilities. The next sections address these areas sequentially. In this context 'subtasks' are additional tasks that serve a main task or activity.

8.3.1.1 *Obtain more personal information*

Interview 1 obtains personal information such as the disability, time of having the disability, and the capabilities of the person. This information directly affects the choice of the technology selection. The Rehab_therapists team suggested obtaining information about previous employment and the place where the person lives.

> *"Previous employment and the place where he is living (big city, small city, village) – resources available for RHB can vary significantly according to this" Rehab_therapists*

The Rehab_therapists team argued that obtaining information about previous employment and where the person lives is important because it significantly affects the resource availability. This is an accurate observation from the points of view of rehabilitation therapists. If the importance of previous employment and where the person lives is investigated from the technology selection point of view, this information enables the conducting of better technology selection. Information about previous employment could provide a view about the type of experience the person with disability could have. The experience is important to detect the complexity level of the technology. Furthermore, information about the place where the person lives could provide views about the environment where the person with disability intends to use the technology and also the attitudes of other people. Moreover, resources such as availability of electricity and the Internet network also have a big impact on the selection of the technology.

As a result, questions about previous employment and the place where the person lives were added to Interview 1 as follows:

What is your previous employment?

Where do you live? E.g. Small city, big city or village.

8.3.1.2 *Determine the type of task*

Detecting the task clearly at the beginning of Interview 1 was a crucial aim as a clear and accurate goal is the base for the rest of the questions in Interview 1. In order to determine the goal of the person Interview 1 includes two questions:

Can you suggest at least THREE activities for which you wish you had technology?

What are the kinds of activities that family members or carers do for you?

However, Rehab_therapists team commented on the previous questions by

> *"All of them want to be healthy as before (walk, control bowels and bladder, have normal life) – will be a challenge, for you will not get any useful answer for RHB from this question.*
>
> *Basically their focus is more to be on reaching premorbid level of physical/concrete status (Walking, Independency in ADLs, driving a car, using the right hand in eating) than reaching a cognitive or different physical but functional level. It worth noting that this question might not assist in determining rehab goals" Rehab_therapists*

By returning back to Phase 1 of MTSF refinement, the researcher tried to adjust these questions to limit the responses of the participants to just include the tasks that can be achieved by electronic technologies as defined by the scope of the research. Some of the people with disabilities neither have any experience using any technology nor know what type of tasks they should provide. Thus, it was discovered in Phase 1 that limiting the type of the tasks that can be achieved using electronic technology did not achieve the required response. As a result, in Phase 2 of MTSF refinement, the researcher led the conversation with the participants using the current questions to get the responses she needed.

Consequently, the response to the Rehab_therapists team comments as regards these questions was to explain how the researcher used these questions in Phase 2 of MTSF refinement to prompt the suitable responses from the participants.

To obtain a useful response to these questions in Phase 2 the researcher started with the first question:

> *Can you suggest at least THREE activities for which you wish you had technology?*

This was designed to open a general discussion about the tasks with which the participant faces difficulty. If the participant mentioned any difficult task that the researcher thought could be eased by using an electronic technology the discussion would focus on this task for the rest of Interview 1. However, if the participant did not mention any difficult task that the researcher thought could be eased using an electronic technology, the second question was:

> *What kind of activities that family members or carers do for you?*

This was asked to prompt discussion of more difficult tasks. Most of the participants mentioned a difficult task that could be eased using an electronic technology as a response to one of these two questions. By reviewing the audio records and transcripts of Interview 1 in Phase 2 for the six participants, the researcher in some cases asked the following question:

> *What are the tasks that you stopped doing because of the disability?*

Consequently, the question:

> *What are the tasks that you stopped doing because of the disability?*

was added to Interview 1 as a prompt question. Thus, the questions of determining the task were amended as follows:

Can you suggest at least THREE activities for which you wish you had technology?

- I wish there is a technology that helps me to:
- What are the kinds of activities that family members or carers do for you?
- What are the tasks that you stopped doing because of the disability?

Furthermore, the above instructions on how to lead the conversation with the participant around to these three questions were added to the instructions regarding how to use the MTSF.

8.3.1.3 *Decompose the task to subtasks*

After Phase 2 of the MTSF refinement, two issues faced by some of the participants were detected in Interview 2 (Evaluation of technology effectiveness). The two issues were that some of the participants were still dependent on someone else in some parts of the task and the additional technology was needed to complete the task efficiently. Thus, a question:

> *Can you break the task to subtasks by dividing the task into steps?*

was added to address these issues.

The reason for adding this question was to enhance the independence of the person by detecting where the person still needs help from others. In addition, this question assists the therapist to decide which additional technology can solve this issue and result in better independence. The Rehab_therapists team commented on the above question with

> *"Even though you are a healthy person you will have troubles describing even simple activities (just try). Do not ask too much from patients, they will not be willing or able to answer*
>
> *For me, this question requires preserved analytical skills which are known to be affected in this population – the clinician might break it down instead." Rehab_therapists*

I think there is a misunderstanding between the researcher and the Rehab_therapists team regarding the meaning of subtasks. However, the way of formulating the question could be the reason for this misunderstanding. The intended actions of the subtasks in Interview 1 were classified as pre-task, during-task, and post-task.

By reviewing the responses of the participants in Phase 2 of MTSF refinement, which led to add the question of decomposing the task to subtasks, most of the responses were related to subtasks that were pre-task, during-task or post-task. For example, pre-task includes what the person does to get ready such as positioning and activating the technology to start the task. During-task includes using additional technology to achieve the best result such as a microphone in the case of the voice input. Post-task includes packing up or completion of a task such as accessing the output by using a printer or headphone. As a result, the following question was added as a prompt question:

Can you break the task into subtasks?

- Can you tell me exactly what you do before, during, and after the task?
  E.g. before: position or activate the technology.
  Task: typing or reading.
  After: print.

8.3.1.4 *Scale of functional capabilities*

MTSF used its own functional capabilities scale in Interview 1, however the Rehab_therapists team recommended using a unified scale to ensure validity and credibility:

> *"I will strongly discourage you to invent your own scales of functional capabilities. Use FIM instead as an internationally validated tool" Rehab_therapists*

Using an internationally recognizable scale enhances the accuracy and standardizes the assessment. The Rehab_therapists team recommended using the FIM™ instrument which is a valid and proven tool in the rehabilitation field and has been used to assess the ability of a person to perform the activities of daily living. The FIM™ instrument involved 18 items: 13 items for physical activities and 5 items for cognitive activities. The items of assessment include activities such as eating, grooming, bathing, and memory. The assessment of the ability to do these types of activities does not give the required information about the ability of moving a specific part of the body for example the hand and also the type of limitation of motion. This information is important to decide which technology can be used given these limitations. Consequently, the decision was to not change the assessment items. The assessment of the scale of the capabilities was:

0 (No ability)

1 (Poor ability)

2 (Fair ability)

3 (Good ability)

4 (Very Good ability)

5 (Excellent ability)

It was changed to:

1 (Extremely limited use)

2 (Quite limited use)

3 (Somewhat limited use)

4 (Slightly limited use)

5 (No limitation)

The purpose of changing the scale of assessment is to make it easier to understand and apply.

In addition the description of each capability was specified by adding items to consider while describing the types of limitation that the person has. The description was modified to include: strength, speed, and balance. Thus, the question regarding the description of the disability was changed to be:

How do you describe your ability in regards to strength, speed, and balance?

Adding these items assists the therapist to be specific about the descriptions they need from the people with disabilities.

8.3.1.5 *Change the language of some questions*

Some comments regarded changing the language of the question to avoid sensitivity of the question for some people with disabilities such as:

Is your disability from birth or at a later stage of your life?

was changed to:

How long have you had the disability?

Sometimes the change of the language of the question was to make the question easier to be understood by people with disabilities. For example:

How does the use of the current technology affect your self-identity?

was changed to:

How does the use of technology affect your view of yourself?

Have all detailed comments been taken into consideration?

At the end of the detailed evaluation, it is worth mentioning that not all the comments from the Rehab_therapists team were considered. The reason was that some of the comments were beyond the scope of this research such as comments on the size of the house in m^2 and questions asking if the house has stairs or ramps or if there is a pavement in the city? In addition, some comments were considered characteristics that were outside the scope of this research such as cognitive abilities.

The next section presents the overall evaluation of the entire MTSF including its four tools.

8.3.2 Overall evaluation

The overall evaluation was conducted in parallel with the detailed evaluation. It included evaluation of the entire MTSF including its four tools (Interview 1, the decision tool, the search tool, and Interview 2). The overall evaluation started by asking Occupational_therapist to answer the questionnaire questions, which focused on the comprehensiveness of the MTSF and to what extent it was effective in guiding the technology selection process in practice. Then, an interview was conducted with Occupational_therapist via telephone to obtain more information and comments as regards her answers. Next, the analysis and discussion of the findings from the overall evaluation are presented.

8.3.2.1 *Usefulness and effectiveness*

The usefulness and effectiveness of the MTSF includes several aspects such as the ability of the MTSF in bridging the gap caused by the lack of a specialist tool for selecting technologies for people with disabilities, how easy it is to be used by novice therapists, the ability of the MTSF to reduce the trial-and-error process, the ability of the MTSF to systemize and unify the assessment of the person’s abilities and needs, and finally the ability of the MTSF to maximize the effectiveness of the recommended technology. The following sections present the analysis and discussion of these aspects in light of the evaluation of MTSF by Occupational_therapist.

Bridging the gap of the lack of a specialist tool

Currently, Occupational_therapist uses assessment tools for function abilities, upper limb strength, and mental health. These tools give her a view about the situation of the joints, muscles, and cognitive abilities. However, the information that she gets from these tools is not enough when she starts to select the appropriate technologies for her patients. Occupational_therapist depends on the Functional Independence Measurement (FIM) to assess the physical abilities of the person with disability. The FIM rates people on a scale of 7 points to show the extent of a person's independence in doing daily activities such as eating, grooming and bathing. I did not use this tool because it does not provide detailed information about the ability of individual body parts (such as fingers, hands or arms). This information is necessary when deciding the most appropriate accessibility technology. Thus, besides the information on the abilities of the people with disabilities regarding joints, muscles, and cognitive abilities, she reported that she needed to ask them more questions to be able to prescribe the appropriate assistive technology

> *"First we assess the patients' abilities by using different assessment tools of abilities such as functional ability assessment, upper limb strength assessment, and mental health assessment. We use these assessment tools to know the types of deformity, which joints the patients were able to use, and the muscle power. Then, we ask them about their age, job, the type of the car they are using, and if they have someone to help. We also check if they need any position aids" Occupational_therapist*

Therefore it is obvious that Occupational_therapist depends mostly on the information about the physical abilities of her patients and some other information such as age, job, type of car, and availability of a caregiver. Despite the importance of this information, the method of Occupational_therapist confirmed the importance of other factors mentioned in the literature as crucial players in the selection of assistive technologies. Other factors included the importance of the person's priorities and preferences (Seymour 2005; Scherer et al. 2007), knowledge and information (Wessels et al. 2003), and environment (Goette 1998; Copley & Ziviani 2005). All of these factors were addressed in detail in the MTSF, which provides a specific framework to select the appropriate technologies by considering all factors that affect the selection process. The availability of the MTSF as a specialist framework for this purpose closes the gap and can avoid the randomness in collecting the required information.

Usable by novice therapists

Occupational_therapist reported that the assessment tools that she used to assess the physical abilities of her patients are specific to this purpose and well known by all occupational therapists in the hospital. The other information that they collect to select the appropriate technologies varies from one patient to another and also varies among occupational therapists as well.

> *"Aside from the assessment tools for the abilities, the other questions differ from patient to another and from therapist to another too" Occupational_therapist*

This indicates that the experience of the occupational therapist plays a significant role in deciding the other important factors and the questions that should be asked to select the appropriate technology. Even though the experience is appreciated and can contribute in better results, the novice who does not have the required experience and is responsible for selecting technologies for people with disabilities can get benefit from a framework that guides the selection process and helps to focus on the required information. The MTSF provides the guidance and focused questions to conduct an appropriate selection of technologies for people with physical disabilities.

Reduce the trial-and-error process

As Occupational_therapist stated they currently do not follow a systematic process to collect the needed information. As a result, they depend more on the trial-and-error process.

> *"Instead we depend more on observing the patients while using the assistive technology in hospital. So if the patient failed to use it successfully, we try something else until we find the appropriate assistive technology" Occupational_therapist*

They prescribe assistive technologies for the patients based on the assessment of their abilities and the little information they have about other aspects such as age, employment, availability of a caregiver or a family member, and the need of position aids.

Asking different questions every time increases the possibility of discovering more gaps after starting the use of the technology in the daily life of the person with disability. This accordingly increases the trial-and-error process until a suitable match is found. The disadvantages of the trial-and-error process are: the time cost because it needs time from both the patient and the therapist to try different technologies; the financial cost, because the technologies are not guaranteed to be successful. The MTSF reduces the number of trial-and-error processes because it considers most of the important factors that affect the use of the technology before prescribing it for the person. This reduces the possibility of discovering difficulties after starting to use the technology in their daily life.

Systematic and unified framework

Occupational_therapist currently depends on random questions that differ based on the situation of the patient and also the experience of the therapist. She appreciated the systematic approach of the MTSF:

> *"We do not have a systematic way for collecting the needed information. Yes, the steps of the framework were very logical." Occupational_therapist*

The MTSF followed a systematic approach to collect information about the abilities and needs of the person with disability. The questions of Interview 1 were divided into themes that helped to focus on the important aspects every time instead of collecting random information. These themes consider most of the needed information to conduct the selection of an appropriate technology. This reduces the number of trial-and-error processes. Therefore, the time and financial costs are reduced and the quality of the technology selection process is increased, as Occupational_therapist indicated:

> *"The framework can facilitate our work and make it better." Occupational_therapist*

In addition, following a systematic approach, to collect the required information for the MTSF, provides a unified assessment for abilities and needs for each patient. This in turn facilitates sharing opinions among therapists, documenting, and obtaining more information from third parties such as family or schools.

Follow-up to maximize technology effectiveness

Prescribing technology for the person with disability is not the last step in the MTSF. The follow-up is a crucial step to ensure that the quality of the technology selection is maximized and to address any further issues that come up after the technology use. Occupational_therapist acknowledged Interview 2 (evaluation of technology effectiveness, the last tool of the MTSF) and its role in detecting any difficulties after using the technology in the actual environment.

> *"I like the assessment of the quality of the selected technology for the patient at the end of the framework because it is very important to know how the patient went with the technology." Occupational_therapist*

Occupational_therapist declared that they usually do not conduct any evaluation for the technology use after the person takes the technology home except to collate the observations of the patient while using the technology in the hospital.

The evaluation of the technology after the use in the actual environment is not less important than the initial assessment. Assessing the abilities of the people with disabilities and observing them while they use the technology in the hospital, as Occupational_therapist assesses and observes, gives a limited view of the actual difficulties. Thus, the use of the technology in the actual environment uncovers additional difficulties as regards the person, the technology, and the environment (Goette 1998; Priest & May 2001; Copley & Ziviani 2005). Hence, comes the importance of Interview 2 to evaluate the use in the actual environment, to discover the actual difficulties, and then to help overcome them for better use.

8.3.2.2 *Comprehensiveness*

As mentioned in the previous section, besides conducting the assessment of the abilities by using tools for functional abilities, upper limb strength, and mental health abilities, Occupational_therapist asks more questions about random aspects such as age, employment, and family to prescribe an assistive technology for a person with disability.

This method of collecting the required information is insufficient due to the high number of difficulties which are discovered after introducing the technology to the person with disability. Another reason for the insufficiency of the current method of collecting the required information is that these questions are different from one patient to another and also from therapist to another as well. Thus, Occupational_therapist reported that the comprehensiveness of the MTSF assists in covering most of the factors before prescribing the technology for the patient

> *"It helps to consider as many factors as we can before coming up with a solution" Occupational_therapist*

Occupational_therapist acknowledged the consideration of the role of family and carers as an influential factor in the successful use of the technology. In some communities, some factors are more important than others. For example, Occupational_therapist is an Arabic therapist. She is aware of the factors that require more consideration than others generally in Arabic countries and specifically in Saudi Arabia where she is working. She acknowledged the consideration of the role of the family in the selection of the technology because she knows that this factor in some cases could completely stop the person with disability using the technology as she stated:

> *"Yes, I felt it was good because all the important factors are there. To be honest I felt that it was someone from the occupational therapy field who wrote the questions. I like the consideration of the family and caregivers because they should be aware of the importance of the technology and also, they should be involved in the process. We should admit that there are families who take the piece of equipment home and do not encourage or help the patient to use it." Occupational_therapist*

The role of the family and carers were widely mentioned in the literature of assistive technology for children with disabilities (Parette et al. 2000; Li & Atkins 2004; Copley & Ziviani 2005). Even though, the focus of this research is on the adult with disabilities and most of them reported that either they do not care about family attitudes towards the technology or that their family are not involved, we still think that the encouragement and support from the family and carers are important for use of the technology.

Another factor that Occupational_therapist considered important was the culture or tradition.

> *"The culture or tradition is also important. For example we do not talk with the patients about the assistive technologies for improving the sexual abilities unless in rare situations such as quadriplegia or someone who married recently." Occupational_therapist*

The impact of the culture on the use of the assistive technologies was mentioned in the literature as well. However, it was excluded from this research as the focus was on the mainstream technologies, which are available for everyone and not specifically designed for people with disabilities. As a result, we consider that the mainstream technologies are not a subject for community culture or tradition.

We believe that every case is different and every case needs different considerations, which leads to asking different questions and focusing on different aspects, with the therapist being the best person to assess the requirement of specific information. However, having a strategic method to collect all the important aspects that are required to conduct an efficient selection of the technology is essential in considering most of the factors that affect the selection of the technology. This is the role of the MTSF.

$MTSF_3$ (Amended version after evaluation phase)

Interview (1): Assessment of needs and abilities

Name ______________________________ Code ______________________________

Age ___________ Gender_____________ Contact details ______________________

Date of interview (1) __________________

Type of disability ____

Brief description ____

____

____

What is your previous employment?

____

Where do you live? E.g. Small city, big city or village

____

1. Tasks (activities)

Can you suggest at least THREE activities for which you wish you had technology?

I wish there is a technology that helps me do:

____

____

____

Ignore the following question in case the participant mentioned a task that can be achieved using an electronic technology in question (1)

____

What are the kinds of activities that family members or carers do for you?

____

____

Ignore the following question in case the participant mentioned a task that can be achieved using an electronic technology in question (2)

What are the tasks that you stopped doing because of the disability?

____

____

Choose one task from question (1), (2) or (3) to complete the rest of the interview.

____

The chosen task is: ____

Can you break the task to subtasks by dividing the task into steps?

Step1: _______________

Step2: _______________

.
.
.
Step N: ______________

Can you tell me exactly what do you do before, during, and after the task?

E.g. Before: position or activate the technology.

During Task: typing or reading.

After: print

Is this task something that you used to do before having the disability (in case of having disability in a later stage of the life)?

____

____

Analysis of current situation:

How do you currently accomplish the task?

What are the advantages of the currently used method?

What are the disadvantages of the currently used method?

Ask the following question in case the participant mentioned non-technological method in question (6.1)

Did you ever use any technology to help you do the task?

Have you had any problems with technology that supported you in the past?

2. Personal information

Abilities

How long have you had the disability?

____

____

How do you rate and describe your ability in regards to the following interaction capabilities?

*Interaction capabilities scale:

1 (Extremely limited use)

2 (Quite limited use)

3 (Somewhat limited use)

4 (Slightly limited use)

5 (No limitation).

Capabilities	Rate	Description
Vision	……....	……………………………..………
Hearing	……....	…………………………………
Somatic (the ability to sense touch)	……....	…………………………………
Audio (speech)	……....	…………………………………
Head control	……....	…………………………………
Shoulder control	……....	…………………………………
Arm control	……....	…………………………………
Elbow control	……....	…………………………………
Hand control	……....	…………………………………
Finger control	……....	…………………………………
Knee control	……....	…………………………………
Foot control	……....	…………………………………

Do you prefer specific methods to interact with the technology?

____

____

____

How does the use of technology affect your view of yourself?

____

____

____

____

3. Environment

Describe the environment where you intend to use the technology?

____

____

How do you want to interact with technology (sitting, on the going)?

____

____

____

How long/ often do you expected to use technology?

____

____

____

How does the attitudes of people around you affect the use of technology?

____

____

____

Do you prefer the technology to be visible or inconspicuous?

____

Do you have any special requirements in regards of?

Technology size ____

Technology weight ____

Technology’s features _______________________________________

Other ____

____

would you like to add anything?

____

____

____

Interview (2): Evaluation of technology effectiveness

Name ______________________________ Code ______________________________

Technology ____

Date of evaluation ____________________________________

How long had the technology ____________________________

Number of times using technology ________________________

1. The goal (needs)

What was your goal?

____

Did the technology help you achieve your goal?

____

____

____

How effective was your technology is (the degree to which the technology meets your needs)?

____

____

____

How does the technology overcome the previous difficulties?

____

____

____

Do you still need help from family members or carers to do any part of the task?

How do you compare the previous method of doing the task and using the technology to do the same task?

Were there other things that you used the technology for?

2. The technology

What was the technology that you used?

What task were you doing using the technology?

What are the advantages of the technology?

How easy was it to use your technology?

How comfortable was your technology (physically and emotionally)?

Where there any difficulties in using the technology?

How does the use of the technology meet your expectations?

How satisfied are you with:

- Physical features (e.g. size, weight)

- External design (e.g. colour, visibility)

- Technical features (e.g. battery, screen brightness)

- Privacy (e.g. sound)

3. The environment

Did you use the technology in the environment you intended to use in? If not why?

How did the technology overcome the environmental barriers (light, sound)?

How does the opinions of people around you affect your continued use of the technology?

Would you continue use the technology in the future? Why?

8.4 Conclusion

This chapter presents the evaluation of the MTSF. The purpose of the evaluation was to ensure the validity of the MTSF and its applicability if it was to be used in occupational or rehabilitation therapy. The evaluation included two tasks: detailed evaluation and overall evaluation. In order to conduct the evaluation tasks therapists were asked to give their opinion as regards the MTSF. In the detailed evaluation a team of rehabilitation therapists was asked to comment on the questions of Interview 1. Most of the suggested modifications from the detailed evaluation tended to improve the questions of Interview 1 to be more applicable in practice such as language clarifying or being more specific about the required information. In the overall evaluation an occupational therapist was asked to answer questions of a questionnaire to evaluate the effectiveness and comprehensiveness of the MTSF. Then, she was interviewed to obtain more information. The findings from the overall evaluation confirmed that the MTSF was comprehensive for most of the important factors that affect the selection of the appropriate mainstream technologies for people with physical disabilities. In addition, it was found that the MTSF will be promising as an effective framework that facilitates the selection process. The next chapter presents the implications of the findings from Phase 1 and Phase 2 of the MTSF refinement on the conceptual framework.

Chapter 9

Refinement of the Conceptual Framework

9.1 Introduction

This chapter focuses on the implications of the findings for the conceptual framework. The findings were drawn from the cases in Chapters 6 and 7. The implications of the findings for the tools of the MTSF were presented for Phase 1 and Phase 2 of the MTSF refinement and evaluation of the MTSF in Chapters 6, 7, and 8 respectively. The implications of the findings for the conceptual framework refine and extend the high-level concepts and develop new relationships between these concepts. A discussion of significant findings that led to the modification of the conceptual framework are presented. Then the modified conceptual framework is presented as a proposed fundamental framework of the interaction between the person and the technology in the disability context.

The chapter starts with the concepts from the findings which influence the technology selection process. Then, the relationships created from the analysis of the findings from Chapters 6 and 7 are presented. Finally, the refined conceptual framework is presented after considering the new concepts and relationships.

9.2 Concepts influencing the selection of technology

In addition to the components of the conceptual framework of this research, some new concepts were found after analysing the findings of the three phases of the refinement of the MTSF. These concepts were either considered with different definitions or not considered in the original version of the conceptual framework. The following sections present these concepts along with a discussion of their importance in connection to the literature.

9.2.1 The role of experience

It was confirmed that both the negative and positive previous experiences of the participants have a strong effect on the performance and acceptance of the technology. Most of the participants who had negative experiences or failure in using a technology in the past did not accept the technology easily and this was reflected in the frequency of the technology use.

By asking them more about their previous experience with technologies, all participants mentioned that they chose the technology for themselves or someone from the family selected it for them. Thus, the selection process that considers their needs and abilities, including the experience to achieve the desired goal, was missing. Moreover, the lack of a follow-up plan to overcome any negative experience aspects was apparent in this situation.

The previous experience of using the technology is rarely and only implicitly mentioned in the literature as one of the important concepts that influence the selection of the technology for people with disabilities. Scherer and Glueckauf (2005) stated that there is a relationship between the past experience of the technology use and performance and the reaction toward the new technology. Positive experience leads to better performance and reaction toward the new technology. This relationship supports the findings from Interview 2 (the last tool of the MTSF which is used to evaluate the effectiveness of the recommended technology) (discussed in detail in Section 6.4.1, Chapter 6). The participants who revealed a negative experience with the past technologies, tended to use the recommended technology less and have lower expectations.

As a result, past experience should be carefully considered in the modified conceptual framework and used as an influencing factor when selecting an appropriate technology; that is, a technology that meets the expectations of people with disabilities and encourages them to explore and use the technology more frequently.

9.2.2 The role of motivation

Another aspect that was revealed during the research process was the role of motivation. It was easy to discover the relationship between the motivation and the frequency of using the technology from the findings. The analysis of this relationship led me to observe other relationships that affect the level of motivation. It was observed that the motivation of the participants not only affected other concepts, it was also influenced by other concepts. The findings showed that there were two other factors which affected the level of motivation. The first factor was the time in life when the participant acquired the disability. The second factor was a task that the participant decided to do after acquiring the disability or something that they used to do before acquiring the disability.

Wessels et al. (2003) explained the relationship between the time in life when the person acquired the disability and the level of acceptance and use of the technology. He stated that when the person acquired the disability later in life the level of acceptance and use the technology are negatively affected. However, if the disability is from birth the level of acceptance and use the technology are positively affected. The reason is because the people who acquired the disability later in their life think that there is no other way they can replace the lost abilities.

The relationship identified by Wessels et al. (2003) corresponds with observed relationships because the rejection of the technology reflects the low rate of using the technology. In addition, it confirms the impact of having the disability from birth or acquiring it later in life. It also explains to what extent the person was getting used to the task before acquiring the disability (discussed in details in Section 7.4.3, Chapter 7).

Consequently, the motivation was presented as a central concept in the refined conceptual framework. The motivation was influenced by the person and the task. At the same time it affected the technology use. This was explained at the start of this section.

9.2.3 The role of expectations

The findings showed irregular expectations from the participants toward the technology. The analysis indicated that the awareness of the potential of technology of the participants could shape their expectations. However, there were inadequate evidences from the findings to demonstrate the relationship between the awareness and the expectations. Even though, it was still worthwhile to acknowledge the importance of the expectations in predicting the success of the selection process. Most of the participants expressed positive expectations toward the technology. In addition, they emphasised that there were many factors contributing to shaping their expectations such as media, working in disability organizations, participating in disability conferences, and traveling to other countries.

The importance of the expectations as indicators of the successfulness of the selection process of the technology was identified by Seymour (2005). Seymour's research corresponds to the findings in this research. The factors that shape the expectations can be understood and improved which leads to better solutions (discussed in detail in Section 7.4.5, Chapter 7).

Thus, the expectations of the people with disabilities is presented as an outcome concept in the refined conceptual framework.

9.3 Relationships influencing the selection of technology

A number of relationships have been mentioned already in the conceptual framework, such as the relationship between the environment and the technology and the relationship between the task and the technology. The next sections present and discuss new and redefined relationships as a result of the findings analysis of this research.

9.3.1 The relationship between environment and technology

The findings presented highlight that the participants showed more concerns about the technology design if they intended to use the technology in public places. This concern came from different factors around the people with disabilities in the environment. The first factor was comprised of possible attitudes the people around them might have had toward the technology, which made them concerned about the technology features such as size, colour, and privacy. The second factor was the physical environment, which made them concerned about features such as screen brightness, battery life, and Internet connection. These findings illustrate the significant impact of the environment on the technology.

The revealed impact of the environment on the technology was consistent with what has been mentioned in the literature about this relationship. Goette (1998) explained how the use of the voice recognition system is affected by the background noise in the surrounding environment. In addition, Priest and May (2001) emphasized the importance of checking the power supply, availability, and the ability to travel with the technology in the environment, before prescribing the technology. Goette (1998); Priest and May (2001), and Copley and Ziviani (2005) suggested that it is necessary to assess and observe the person with disability while using the technology in the actual environment in order to overcome any environmental difficulties.

The relationship between the environment and the technology is obvious in the literature. However, there is a need to define this relationship and elaborate how the technology copes with the environment for effective performance. The environment-technology fit relationship was defined in the conceptual framework to consider the following aspects: size, weight, external design, privacy, screen brightness, battery life or power supply, and Internet connection (discussed in detail in Section 6.4.4, Chapter 6).

9.3.2 The relationship between task and technology

The task-technology fit relationship was defined in the conceptual framework. However, the analysis of the findings elaborated the relationship. The findings showed that to accomplish a better fit between the task and technology, factors such as time, effort, pain, and/or the quality of the outcome should be considered. Some participants who revealed that they stopped using the technology mentioned that they needed a long time to accomplish the task such as using a head stick for writing. Others inferred the reason of stopping using the technology to be the pain or the effort they experienced while using the technology such as using one hand for typing on a traditional keyboard. The lack of proficiency was another reason for stopping the use of the technology, such as the use of a mobile keyboard leading to many typographical errors.

Goette (1998) stated that achieving a good task-technology fit guaranteed a successful technology solution. He emphasized the effectiveness of the technology to achieve the specified task. Sometimes the technology provided more features than the people with disabilities needed making them overwhelmed by the number of options they had. The analysis of the findings confirmed the aspects of effectiveness and proficiency. However, it was observed that the time needed to complete the task and the effort and/or pain also contributed to a better task-technology fit relationship (discussed in details in Section 6.4.5, Chapter 6).

Consequently, based on the discussion above the task-technology fit relationship was added to the conceptual framework to include the time, effort, and pain beside the quality of the outcome.

9.3.3 The relationship between self-identity and technology

It was observed that some of the participants who showed successful technology use revealed that they would not continue using the technology in the future. It was found that there was a conflict between the participants' needs and their preferences. The participants' needs included such technologies as a big screen for better display or a keyboard with bigger keys for more control. The participants' preferences mostly related to the size, weight, and external design of the technology. Thus, the analysis first tended to discover the reason of the conflict between the needs and preferences.

Most of the participants had a common agreement that they did not want to draw attention to their disabilities, even though that all of them were using wheelchairs and the provided technologies were mainstream technologies. Thus, the analysis tended to find out more about the reasons that prevented these participants from using the technology.

One explanation for this could be the view of self, which was reported by Pape et al. (2002) and Gooberman-Hill and Ebrahim (2007), as the people with disabilities might stop using the assistive technology if it promotes a negative self-identity or does not meet their own view about themselves. This corresponded with findings, as the participants stopped using the technology because it conflicted with their desire to prove that they were still able to think, communicate, and express themselves (discussed in detail in Section 7.4.4, Chapter 7).

As a result of self-identity and technology affecting each other, the relationship between the self-identity and the technology use was created as a dual relationship.

9.4 Refined conceptual framework

The activity theory played a crucial role as a fundamental theoretical framework for this research. Through the high level concepts of the activity theory, the factors affecting the selection of the technologies for people with disabilities were grouped and classified. As a result, the conceptual framework of this research was generated. See Chapter 4 for the complete process.

Figure **9.1** shows the refined conceptual framework. It presents the important concepts to conduct an appropriate selection of technology and how these concepts interact in the context of disability.

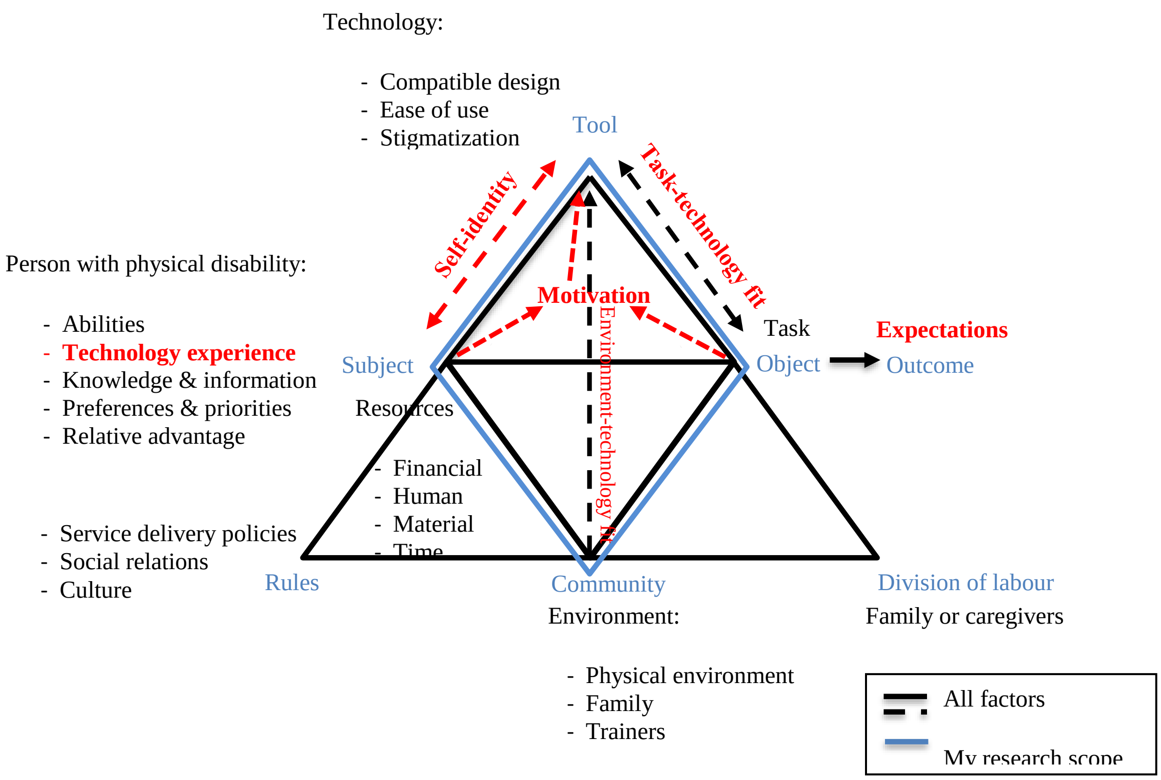

Figure 9.1. Refined conceptual framework

The research confirmed the proposed classification of the important concepts that lead to selecting an appropriate selection of the technology in the context of the disability. The proposed concepts include the person with disability, technology, task, and environment. They played a crucial role in the selection of the technology. However, from the findings more concepts emerged which had an impact on the selection of the technology such as the motivation and the expectation.

It further confirmed the relationships and the interactions between these concepts. A change in any concept leads to a reassessment of all concepts and a reconsideration of their interdependency.

The research also confirmed the importance of the proposed relationships between concepts such as task-technology fit and the impact of the environment on the technology. Furthermore, the findings showed that there was a need to redefine or extend some relationships. In addition, the findings presented a new relationship between the person with disability and the use of the technology based on self-identity.

9.5 Conclusion

The discussions in Chapters 6, 7, and 8 led to refining the tools of the MTSF. This chapter discussed the significant findings that led to refining the conceptual framework. The experience, motivation, and expectations were presented and discussed in regard to the findings and literature. There was then a discussion of how these concepts fit into the refined conceptual framework. Next, a discussion on the extended, elaborated, and emerged relationships was presented. Finally, a refined conceptual framework was presented including the new and redefined concepts and relationships. The next chapter, the conclusion chapter provides a review of the research objectives and process. Moreover, it presents the limitations and contributions of this research in both practical and theoretical aspects.

Chapter 10

Conclusion

10.1 Introduction

In the conclusion of this research, each of the research questions are addressed and the extent to which they are solved is explained. Next, the contributions of this research in terms of theory and practice are offered. Finally, it includes some limitations and recommendations for further research.

10.2 Overall summary

This research has presented the Mainstream Technology Selection Framework (MTSF), a new framework to assist specialists, who are responsible for recommending technologies for people with disabilities, to select the most appropriate and effective technologies for them. The MTSF includes four instruments: Interview 1 (assessment of abilities and needs), a decision tool, a search tool and Interview 2 (evaluation of the technology effectiveness). The MTSF has been applied and tested in two phases. First, Interview 1, the decision tool, and the search tool were applied in Phase 1 using two hypothetical cases. Based on the findings from Phase 1 the instruments of the MTSF were refined then used in the next round of refinement. Next, Interview 1, the decision tool, the search tool, and Interview 2 were applied in Phase 2, using six real cases. Then, the MTSF was evaluated by a team of three rehabilitation therapists and one occupational therapist. Finally, the initial conceptual framework was refined based on the findings from the MTSF instruments. The findings also were compared and synthesised to provide answers to the research questions.

The following sections present a discussion of the extent to which the research questions were addressed.

Q1: What are the factors that affect the selection of mainstream technologies for people with physical disabilities?

The found factors from the literature that affect technology use were classified and grouped under each concept of the activity theory and then used to develop the instruments of the MTSF. Thus, these factors were considered in the selection process of mainstream technologies for people with physical disabilities. It was found that most of the factors that affected the use of the mainstream technologies corresponded with the factors that affected the use of the assistive technologies such as personal characteristics, goal detection, preferences, and the environment. However, some interesting differences were identified. For example, the role of the environment took higher priority than was expected, even though the solutions were selected from the available mainstream technologies. Furthermore, it was recognized that acknowledging the experience of the person with disability regarding the use of the technologies played a significant role in the selection process regardless the nature of the experience (positive or negative). This was found despite the fact that the role of the experience was rarely mentioned in the literature. Moreover, there was a difference between the knowledge of the person and the experience even though they both affected the selection of the technologies. The knowledge refers to any information the people with disabilities acquired, whether from their own use of the technologies or from other resources such as friends, family, or media. Whereas experience can only be obtained from the direct use of the technologies which explains the significant impact of the experience. In addition, it was recognized that the motivation to use mainstream technologies was affected by the time when the person started doing the desired task. So that if the person used to do the task before acquiring the disability, the motivation level mostly will be high. On the other hand, a person who hadn't done the task before acquiring disability would be very unlikely to gain high motivation. This finding corresponded with the literature that mentioned the relationship between the acceptance of the technology and the time when the person started doing the desired task. It was stated in the literature that people who acquired disability from birth were more likely to accept using assistive technologies.

Q2: Can a framework aid the matching of people who have disabilities to effective mainstream technologies?

The MTSF was used to select effective mainstream technologies for the participants. First, Interview 1 was conducted to assess a participant's needs and abilities. Next, the decision tool was used to translate the needs and abilities to technology features. Then, the search tool was used to search for a technology containing these features by using a search engine. Finally, after providing the technology for the participant and using it for a while, Interview 2 was conducted to evaluate the effectiveness of the mainstream technology solution. Most of the participants reported that they achieved 70- 90% of their own desired goals. In addition, the findings about the effectiveness of the solutions demonstrated that the mainstream technology solutions needed less effort and time. They were mostly easier to use, faster, more flexible, had more options, and added no pain or discomfort to the participants' experiences. It was found from the evaluation by the rehabilitation and occupational therapists that the MTSF can bridge the gap caused by the lack of a specialist tool for selecting effective technologies for people with disabilities. The existing tools therapists currently use are specific for the assessment of the physical abilities and not specific for selecting technologies. Furthermore, the MTSF can be used by novice specialists who lack knowledge of the important factors that affect selection of effective technologies. It was also recognized that the comprehensiveness of the MTSF for most of the factors that affect the selection of the effective technologies reduces the trial-and-error process. The reason for this is that the MTSF minimizes the chances of discovering new issues after recommending the technology. Moreover, it was perceived that the systematic approach of the MTSF, including the follow-up after using the technologies in the actual environment, can improve the effectiveness of the recommended technologies for people with physical disabilities.

Q3: Can mainstream technologies be effective alternatives to traditional assistive technologies for people with physical disabilities?

The work resulted in many promising findings regarding use of mainstream technologies to assist people with physical disabilities. The findings included tolerance of the input/output channels, the effectiveness, diversity of the mainstream technology features, and social and environmental friendliness. First, the tolerance of the input/output channels of the mainstream technologies offered an opportunity for people with physical disabilities to overcome their previous difficulties. It was recognized that some adaptations of the input/output channels such as mouse features made a significant improvement in the performance of the person with disability. This corresponds with the literature on using mainstream technologies for people with disabilities. In addition, the diversity of the input/output channels of mainstream technologies offered alternative options for maximizing comfort and accuracy such as using a voice recognition system instead of a touch screen. Second, the effectiveness of the mainstream technologies covered different aspects such as successfulness in achieving desired goals, reducing the time to accomplish tasks, and the ability to perform more tasks than were mentioned in the first assessment. Third, the diversity of the mainstream technology features provided a wide range of creative solutions. Finally, it was found that mainstream technologies were friendly in terms of social and environmental use as they were generally available and accepted. However, on the other hand, it was also found that few technologies supported the Arabic language, which made finding a solution for some cases difficult. For example, there was difficulty in finding a voice recognition system that supported Arabic. To sum up, the mainstream technologies with some adaptations were in most cases effective affordable alternatives. The adaptations were made to the technology features and/or input/output forms to accommodate the needs of people with physical disabilities.

10.3 Research contribution

The next two sections present the contributions of this research theoretically and practically.

10.3.1 Theoretical contribution

The theoretical contribution of this research adds to the body of knowledge in regard to technology selection for people with disabilities. The detailed theoretical contribution is as follows:

The implementing of the activity theory in the disability context for the purpose of selecting an appropriate technology is new and innovative. This research provides a conceptual framework based on activity theory. The conceptual framework classified and grouped the factors that affected the selection of the appropriate mainstream technology for people with physical disabilities under four concepts: personal characteristics, technology features, desired task, and environment. In addition, the theoretical framework provided an explanation of the relationships between these concepts, including self-identity, environment-technology fit and task-technology fit. The findings support the notion that the consideration of these four concepts and the interactive relationships between them offers an effective process to conduct an appropriate selection of the mainstream technology.

This research also empirically confirmed the conceptual framework by using the conceptual framework to develop the instruments of the MTSF. Then, the findings from these instruments demonstrated that the important factors that affect the selection of the mainstream technology for a person with physical disability have been covered.

This research contributes to the activity theory by redefining its high level concepts and presenting the subfactors under each concept and explaining the relationships between concepts. This research demonstrated that the activity theory can reasonably be applied in the context of disability. The activity theory is also able to guide the process of selecting an appropriate mainstream technology for people with disabilities.

This research contributes to the knowledge of technology selection by providing evidence that the factors affecting the selection of assistive technologies could be applicable to mainstream technologies as well.

10.3.2 Practical contribution

The practical contribution can be presented as follows:

It has been mentioned throughout the thesis that there was no framework or model that followed a systematic approach with fully developed instruments to guide the selection process of appropriate technologies for people with disabilities. The Mainstream Technology Selection Framework (MTSF) fills this gap to assist specialists in making better decisions. It also assists in providing a specific answer about the appropriate features of the technology for each case and that consequently reduces the trial-and-error process. Thus, applying the MTSF reduces the time and effort from both the specialists and people with disabilities to find the most effective mainstream technology match.

This research confirms the ability of the mainstream technologies in some cases to be effective and affordable alternative options for people with physical disabilities. This confirmation increases awareness of the benefits of the mainstream technologies for people with disabilities of both the providers of the technologies and people with disabilities. They should consider mainstream technologies as one of their options. The technology specialists should increase their knowledge about what the mainstream technologies can offer for people with disabilities. The people with disabilities also need to explore the available technology solutions including the mainstream technologies which may be already owned by them.

10.4 Limitations and further research

In spite of the contributions of this research, it has several limitations which could lead to further research in the future. First, recruiting a larger sample was one of the important challenges of this research. In this context, it is worth mentioning that this research faced significant difficulties in finding participants both in Australia and Saudi Arabia. The reason for that could be that the people with disabilities already have a difficulty managing their own daily life without adding further things to do such as participating in a research project.

In addition, the lack of literature on practical evaluation of the effectiveness of existing models and frameworks for technology selection processes, limits the ability to compare the findings of this research with the previous ones. However, the researcher compared the existing models against criteria of successful technology selection processes and adopted beneficial components into the MTSF.

A future research study could study the interaction of tradition and culture with technology in the disability context, from the points of view of both the specialist and the person with disability.

Furthermore, the MTSF could be refined to be applicable to other types of disabilities such as blindness and deafness. This could be done by first refining the conceptual framework to include the factors that affect the use of the technology for each type of disability, then refining the instruments of the MTSF and applying them in practice.

A future research study could be conducted to compare the cost-effectiveness of the mainstream technologies and the assistive technologies, which will help to explore and understand the issues that lead to the best technology investments.

10.5 Conclusion

This chapter presented the key and significant findings that answered the research questions. Then, the theoretical and practical contributions of this research were introduced. Finally, the limitations of this research including time limitations and difficulties of finding participants and technologies for this research was presented along with paths for further research.

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Appendices

Appendix A: Explanatory Statements and Consent Forms

MONASH University

Explanatory Statement (Phase 2: main cases)

Title: Finding and Applying Mainstream Technology Solutions for people with Disabilities

This information sheet is for you to keep.

My name is **Mona Asiri** and I am conducting a research project with **Dr. Kirsten Ellis** a **senior lecturer** in the Department of **Information Technology** towards a **degree of PhD.** at Monash University. This means that I will be writing **a thesis which is the equivalent of a 300 page book, journal article, conference presentation, oral presentation and presenting results on-line.**

You are invited to take part in this study. Please read this Explanatory Statement in full before making a decision.

Why were you chosen for this research?

You were recruited for this research through the disability organization. All people with a physical disability in the upper body (excluding hearing, visual and cognitive disability), able to communicate verbally and 18- 30 year of age were potential research subjects.

The aim/purpose of the research

The aim of this study is to choose the appropriate mainstream technology for you.

I am conducting this research to find out how I can match your abilities with the appropriate features of the mainstream technologies.

What does the research involve?

The study involves **audio recording and semi-structured interviews.** There will be two interviews the first will be at the beginning of the project and the second will be after using the technology for a period of time depends on your situation. During that time, you will use the recommended technology and keep a log of your experience. Both interviews will be likely conducted at the Muscular Dystrophy association.

How much time will the research take?

Activities	Time	By whom
Interview (1)	Maximum 1 hour	Researcher & you
Applying the assessment tool to select the mainstream technology which involves: 1. The researcher will match your abilities with the appropriate technology features. 2. The researcher will recommend a mainstream technology for you based on your abilities and needs.	Maximum 1 week	Researcher
Introducing the mainstream technology device to you and make sure that every aspect is considered	Maximum 1 hour	Researcher & you
Install the mainstream technology	Maximum 1 hour	Researcher
Continue using the mainstream technology device in your day-to-day life.	Based on situation (at least 1 week)	You
keep a log about the using of the mainstream technology	For every use	You
Interview (2)	Maximum 1 hour	Researcher & you

Inconvenience/discomfort

Other than being available for the research there should be no inconvenience or discomfort to you. However, if you have any problem during any stage of the research you can ask for a break to rest also, the interview can be postponed and continued in a follow up session.

Participation and Payment

Participation is voluntary; there is no payment for participating in this research.

You can withdraw from the research

Being in this study is voluntary and you are under no obligation to consent to participation. However, if you do consent to participate, you may withdraw from further participation at any stage but you will only be able to withdraw data prior to the analysis phase of the research as at this stage the data will no longer be identifiable.

Confidentiality

You will not be identifiable from the results.

Storage of data

Data collected will be stored in accordance with Monash University regulations, kept on University premises, in a locked filing cabinet for 5 years. A report of the study may be submitted for publication, but you will not be identifiable in such a report.

Results

If you would like to be informed of the aggregate research finding, please contact Mona Asiri on +[redacted] The findings are accessible for one year.

If you would like to contact the researchers about any aspect of this study, please contact the Chief Investigator:
Dr. Kirsten Ellis Monash University Berwick Campus, Clyde Road, Berwick Victoria, 3806, Australia [redacted]

Thank you

Mona Asiri

MONASH University

Consent Form (Phase 2: main cases)

Title: Finding and Applying Mainstream Technology Solutions for people with Disabilities

NOTE: This consent form will remain with the Monash University researcher for their records.

I understand I have been asked to take part in the Monash University research project specified above. I have had the project explained to me, and I have read the Explanatory Statement, which I keep for my records.

I understand that:	**YES**	**NO**
• I will be asked to be interviewed by the researcher	☐	☐
• I understand that I will be asked to allow the interview to be audio-taped.	☐	☐
• I will be asked to use an assistive technology for at least 3 months	☐	☐
• I will be asked to keep a log of using the assistive technology	☐	☐

and

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way. However, I will only be able to withdraw data prior to the analysis stage of the research as at this stage the data will no longer be identifiable.

and

I understand that any data that the researcher extracts from the interview and audio tape for use in reports or published findings will not, under any circumstances, contain names or identifying characteristics.

and

I understand that data from the interview and audio recording will be kept in secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5 year period unless I consent to it being used in future research.

and

I understand that I will remain anonymous at all times in any reports or publications from the project.

Participant's name: ______________________________

Signature: ______________________ Date: ______________

If unable to sign name:

Method of consent: ______________________________
Witness's signature: ______________ Date: ______________
Witness's name: ______________________________

Explanatory Statement (For Technology Specialists)

Title: Finding and Applying Mainstream Technology Solutions for people With Disabilities

This information sheet is for you to keep.

My name is **Mona Asiri** and I am conducting a research project with **Dr. Kirsten Ellis** a **senior lecturer** in the Department of **Information Technology** towards a **degree of PhD.** at Monash University. This means that I will be writing **a thesis which is the equivalent of a 300 page book, journal article, conference presentation, oral presentation and presenting results on-line.**

You are invited to take part in this study. Please read this Explanatory Statement in full before making a decision.

Why were you chosen for this research?

All people who take part in technology-person matching decisions were invited to participate.

The aim/purpose of the research

The aim of this study is to choose appropriate mainstream technology for people with physical disabilities. I am conducting this research to determine the effectiveness of the Technology Selection Framework tool that I designed for matching people's abilities with the appropriate features of mainstream technologies.

What does the research involve?

The study involves **questionnaire.** I need the specialist to review the framework. Then, the specialist will be asked to answer the questionnaire based on his/her view regarding effectiveness of the framework tools and their experience in the technology-person matching field. Finally, the specialists will thankfully return the questionnaire back to the researcher on her email:[redacted]

Inconvenience/discomfort

Other than being available for the research there should be no inconvenience or discomfort to you.

Participation and Payment

Participation is voluntary; there is no payment for participating in this research.

You can withdraw from the research

Being in this study is voluntary and you are under no obligation to consent to participation. However, if you do consent to participate, you may withdraw from further participation at any stage but you will only be able to withdraw data prior to the analysis phase of the research as at this stage the data will no longer be identifiable.

Confidentiality

You will not be identifiable from the results.

Storage of data

Data collected will be stored in accordance with Monash University regulations, kept on University premises, in a locked filing cabinet for 5 years. A report of the study may be submitted for publication, but you will not be identifiable in such a report.

Results

If you would like to be informed of the aggregate research finding, please contact Mona Asiri on +61399052470 or email maasi1@student.monash.edu. The findings are accessible for one year.

If you would like to contact the researchers about any aspect of this study, please contact the Chief Investigator:	If you have a complaint concerning the manner in which this research: CF12/3890 - 2012001853 is being conducted, please contact:
Dr. Kirsten Ellis Monash University Berwick Campus, Clyde Road, Berwick Victoria, 3806, Australia [redacted]	Dr. Maha Al-Ammari Assistant professor of Applied Mathematics King Saud University Riyadh, Saudi Arabia P.O. Box 226795, Postal Code 11324 [redacted]

Thank you

Mona Asiri

MONASH University

Consent form (For Technology Specialists)

Title: Finding and Applying Mainstream Technology Solutions for people with Disabilities

NOTE: This consent form will remain with the Monash University researcher for their records.

I understand I have been asked to take part in the Monash University research project specified above. I have had the project explained to me, and I have read the Explanatory Statement, which I keep for my records.

I understand that:	YES	NO
• I will be asked to answer a questionnaire	☐	☐
• I will be interviewed by the researcher	☐	☐

and

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way. However, I will only be able to withdraw data prior to the analysis stage of the research as at this stage the data will no longer be identifiable.

and

I understand that any data that the researcher extracts from the questionnaire for use in reports or published findings will not, under any circumstances, contain names or identifying characteristics.

and

I understand that data from the questionnaire will be kept in secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5 year period unless I consent to it being used in future research.

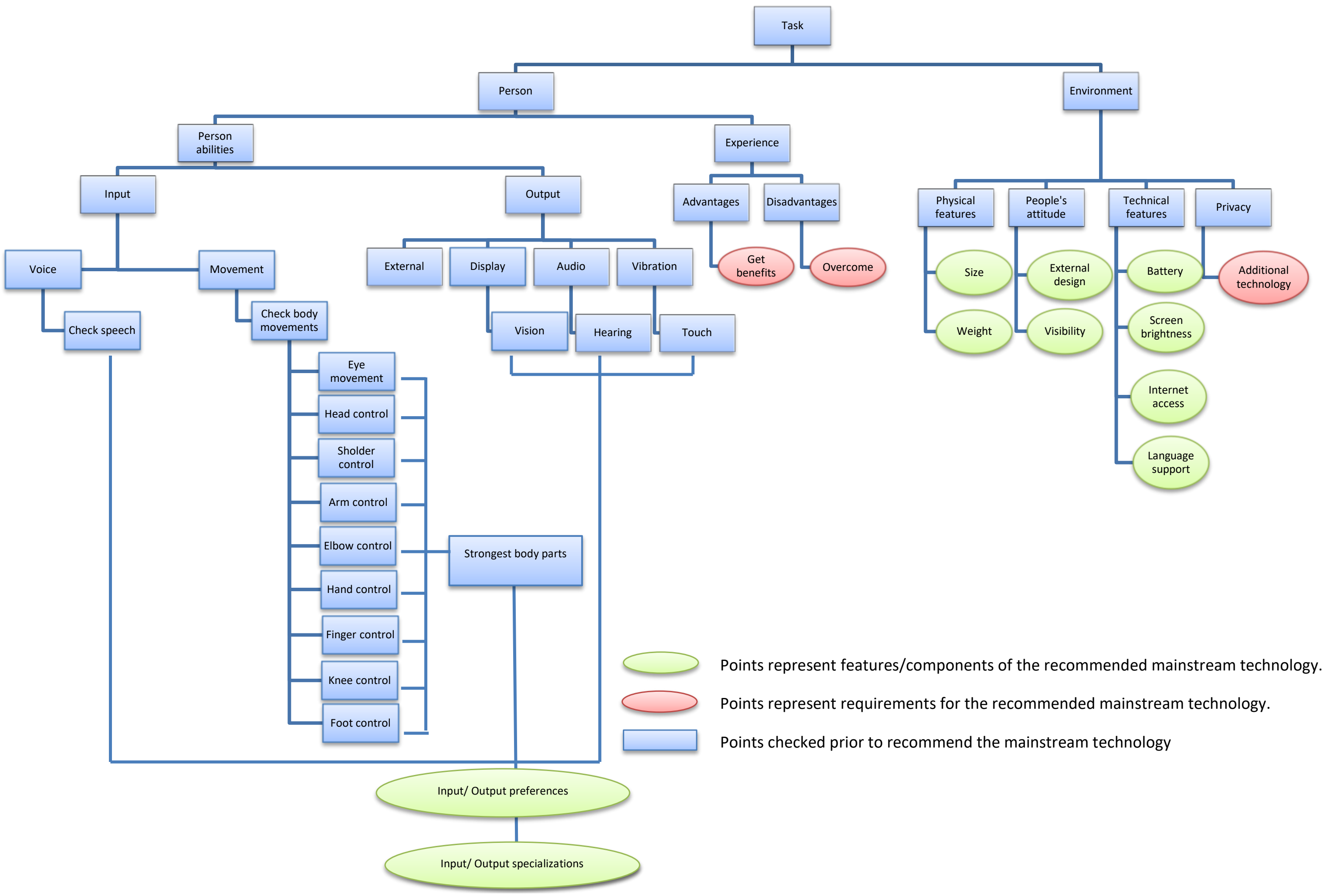
and

I understand that I will remain anonymous at all times in any reports or publications from the project.

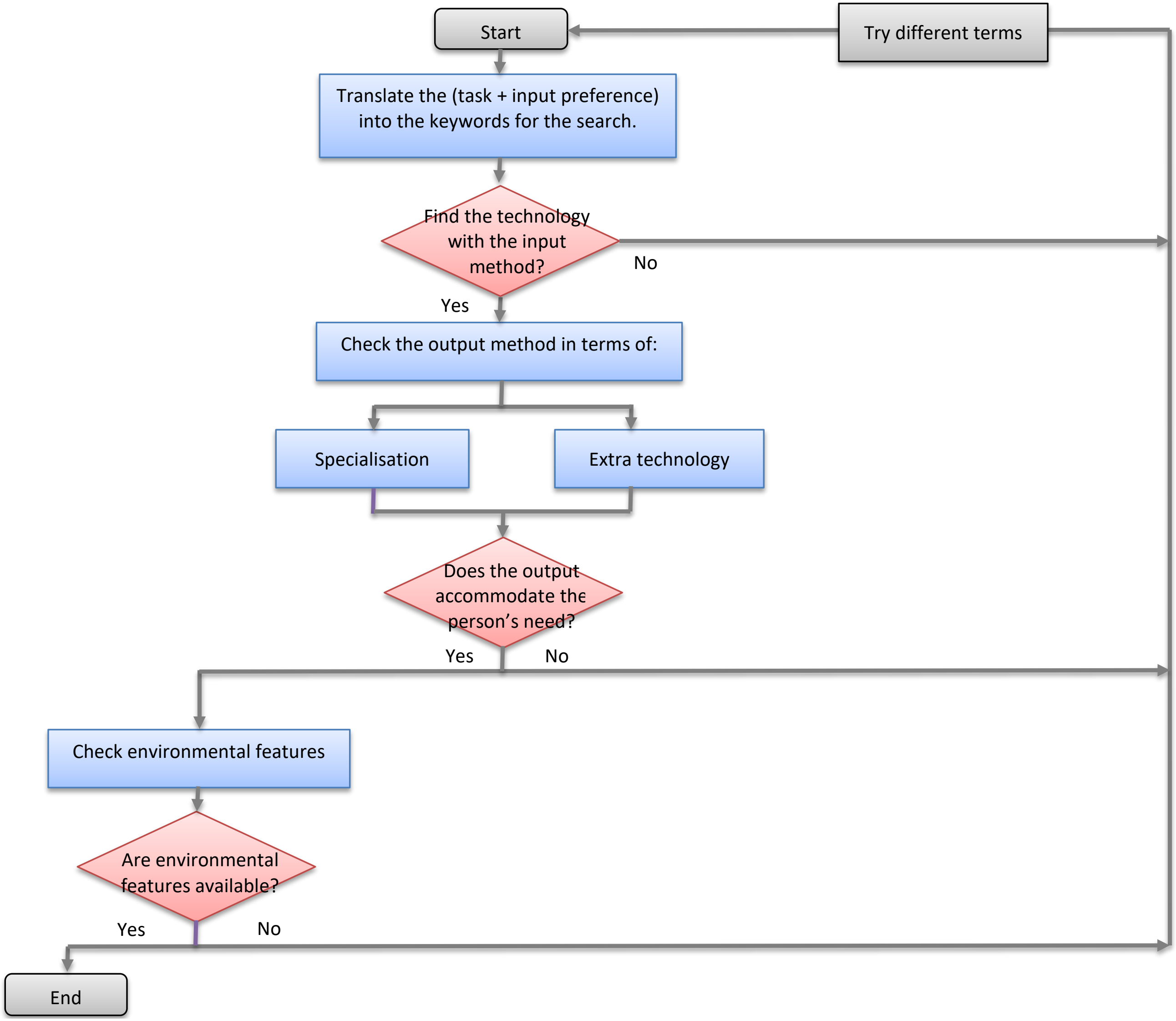
Specialist's name: ____

Signature: ___________________________ Date: ______________________

Appendix B: The Final Version of the Decision and Search Tool



The final version of the decision tool



The final version of the search tool

Appendix C: Booklet of the Evaluation Phase

Mainstream Technology Selection Framework

Evaluation Phase

Mona Asiri

Monash University

2016

Dear ……………,

I am emailing to invite you to evaluate the mainstream technology selection framework (MTSF) which I developed and tested as part of my PhD research. As a highly skilled consultant physiatrist you have the expertise required to conduct an evaluation of the framework in regards to its completeness and usability. The framework is in the attached documents, which consist of the four major parts: a description of the framework tools, instructions for using the framework, a copy of the framework and the evaluation questions.

Please review my attached document for additional details regarding the MTSF. I will follow up to request an appointment to discuss your responses to the evaluation questions.

Please feel free to contact with me if you have any questions.
Thank you for your time and consideration.

Sincerely,

Mona Asiri
maasi1@student.monash.edu

Overview of Mainstream Technology Selection Framework

The mainstream technology selection framework (MTSF) has been created by the researcher (Mona Asiri) for her PhD research. This document includes the MTSF's objective, its components, instructions on how to apply it, and questions for the expert's evaluation of it.

Framework's Objective

The MTSF's main objective is to assist people in finding alternative and affordable mainstream technology (MT) solutions for people with physical disabilities. The underlying rationale is that the mainstream technological devices, such as tablets, mobile phones, entertainment systems, and voice recognition systems, are much cheaper than the assistive technology (AT) which is specifically designed for people with disabilities.

Framework's Description

The MTSF has been developed and tested to provide a usable and complete tool for specialists who try to identify an appropriate technology for people with physical disabilities. The framework includes two interviews, a decision tool and a search tool (see Figure 1). These instruments can help specialists recommend the appropriate mainstream technology for people with disabilities.

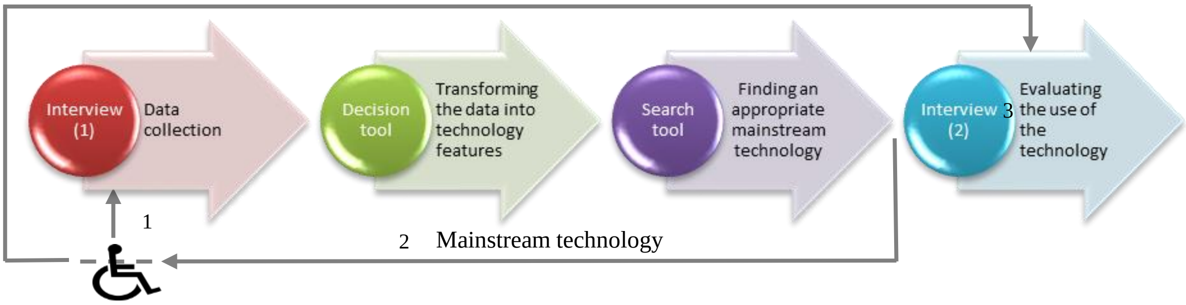


Figure 1: Mainstream technology selection framework workflow.

Basic Components of the Framework

Assessment of needs and abilities (Interview 1)

The semi-structured Interview 1 (Appendix 1) aims to collect data about three main themes for use in the decision tool. The specialist addresses the interview questions to the person with the disability.

Decision tool

The decision tool (Appendix 2) is the second stage of the MTSF. At this stage, the data collected from Interview 1 are transformed into technology features.

Search tool

The search tool (Appendix 3) is the third stage of the MTSF. A flowchart diagram represents the process of searching for a mainstream technology, using the information generated from the decision tool. Through research, the aim is to find a mainstream technology (e.g., via technology magazines, technology databases, or the Internet) that meets the person's needs based on the data collected from Interview 1 and processed by the decision tool.

Evaluation of technology effectiveness (Interview 2)

Following the semi-structured approach of Interview 1, Interview 2 aims to evaluate the effectiveness of the recommended MT. Interview 2 includes three themes: the goal, the technology, and the environment (see AC.3).

Instructions for using the MTSF

The framework is intended for use with people with physical disabilities (excluding vision, hearing and cognitive impairments). Here, the term "physical disabilities" refers to any type of restricted motion, regardless of the reasons for the restriction. Common physical disabilities among young adults include cerebral palsy, multiple sclerosis, and spinal cord injury.

Interview 1

1. Using Interview 1, collect the data from the person with the physical disability.

From Interview 1 to the decision tool

Transfer the collected information from Interview 1 to the decision tool (decision tool in AC.1) by following the next steps.

2. Transfer an identified task in Interview 1 to the task node on the decision tree. (For example, the task "type on the computer keyboard with both hands" is transferred as "faster typing").

3. Transfer the analysis of the current situation to the experience node on the decision tree, so the person can benefit from the advantages and overcome the disadvantages. (Example of an advantage: If the person feels comfortable using a small table attached to the wheelchair, the recommended technological device can be placed on the table. Example of a disadvantage: The lack of fine motor skills can be overcome by providing an alternative access method, such as voice recognition, for more accurate results).
4. Transfer the assessment of the person's abilities to the input nodes on the decision tree. The input node branches out to the person's abilities (including voice and movement) that enable him or her to send an input to the technological device. Transfer the assessment rate of each ability to the matching node on the decision tree. Detect the strongest input abilities based on their respective rates.
5. The output node branches out to the output forms that the technology can provide, which include external output, display, audio and vibration. Transfer the assessment rate of each ability to the matching node of each output form on the decision tree.
6. Transfer the person's preferred interaction input/output methods (collected in Interview 1) to the input/output preferences node to compare the person's preferences with his or her abilities. The decision regarding the best input/output method is based on the proper balance between the preferences and the abilities to achieve the best results. (For example, the person's strongest body part is the head, with 5 points on the assessment scale, but he or she prefers the hands, with 3 points on the scale. Therefore, the person's preference is given priority over his or her ability as long as he or she has a reasonable ability to achieve the goal).
7. For the input/output specialisation node on the decision tree, compare the final detected input/output methods with the person's abilities and consider the suitable technology customisation to provide easy and comfortable access. (For example, the person prefers using his or her hands as an input method although these are weak. Hence, adaptation is needed, such as an attached keyboard with large and appropriately spaced keys. In terms of output specialisation, for example, a headphone for making calls can provide privacy for a person with hearing difficulty).
8. Transfer the environment information in Interview 1 to the environment node on the decision tree. The environment node branches out to the external design of the technology, the technical features and the requirement for any additional hardware or software.

- Determine the external design of the technological device, including its size and weight, based on the person's requirements. Identify the device's conspicuousness based on the person's response to the question in Interview 1 about the attitudes of the surrounding people. (For example, if the person is concerned about how other people look at him or her and how he or she performs the task, the external design of the technology device should be considered).
- Review the technical features based on where the person intends to use the device. (For example, if the person intends to use it outdoors, the battery life and the screen brightness should be checked). Decide on other technical features according to the requirements of the main task. (For example, if the main task is accessing social network sites by using the voice recognition system, the technology should provide Internet access and support the user's language).
- Regarding the last branch of the environment node on the decision tree, the technology should satisfy the privacy requirements of the person. (For example, if the person has a weak sense of hearing, providing an additional device such as a headphone is important to protect his or her privacy while using the main technological device outdoors).

9. After completing the use of the decision tool, you will have the following features of the technology for the detected task:

- input/output methods, including any specialisations;
- external design (size, weight and conspicuousness);
- technical features (battery life, screen brightness, Internet access and language support); and
- any necessary additional technology (software or hardware).

From the decision tool to the search tool

Use the generated technology features in the previous phase to search for the appropriate technology by using a search engine (such as Google) and following the next steps:

10. Translate these generic terms into the specific keywords for the search (task + preferred interaction method = type of the technological device). For example, (faster typing + hands = keyboard).

11. Translate these generic terms into the specific keywords for the search (type of the technological device + input specialisation = first group of search terms). For example, (keyboard + touch or soft keys = keyboard, touch, soft, keys).

12. Use the search engine to search for the first group of words. In this example, (first group of search terms = keyboard, touch, soft, keys).

13. Once the technology that satisfies the input specialisation is found, check whether the technology output also accommodates the person's weaknesses by providing extra technology or customising the technology feature. For example, the technology should accommodate a person's poor vision by having a large screen or large text. If the person needs to print the output, a connection to the printer should be provided. Customising the technology features, such as the settings of the mouse cursor, is important in case the person lacks fine motor skills.

14. Finally, check the candidate technology against the environment features (size, weight, battery life, screen brightness, Internet access, and support language), each according to the person's needs.

15. Once the technology accommodates the environmental factors, it is considered a technology solution for the person.

Interview 2

Conduct Interview 2 (see AC.3) after giving the technology to the person with disability to use for a period of time, to evaluate the effectiveness of the technology solution by following the next steps:

16. Collect the data about the experience of the person with a physical disability when using the recommended technology.

17. Provide support for the person to overcome any difficulty he or she faces while using the recommended technology.

18. Consider any issue that has not been covered in Interview 1 or has newly emerged during the use of the recommended technology.

Questions (Evaluation Phase)

Your responses as an expert in the field will be valuable for the research and will be used to further improve the overall framework and its components.

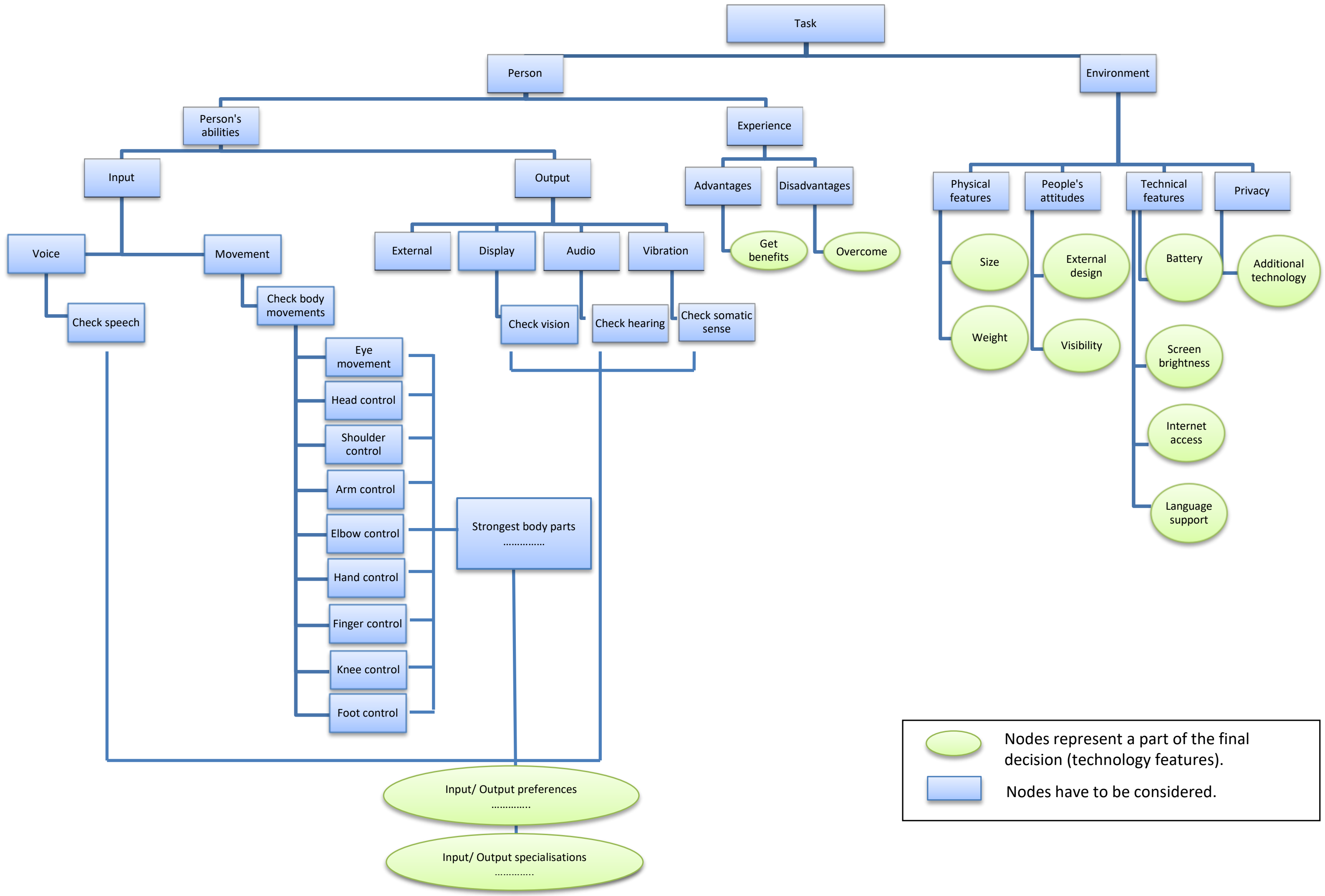
Please answer the following questions by number, and save them in a new document.

1. What type of work do you do?
2. How long have you been doing this kind of job?
3. How do you currently identify an appropriate technology for people with disabilities? Do you have any tool (tools) to assist you? How effective is (are) this (these)?

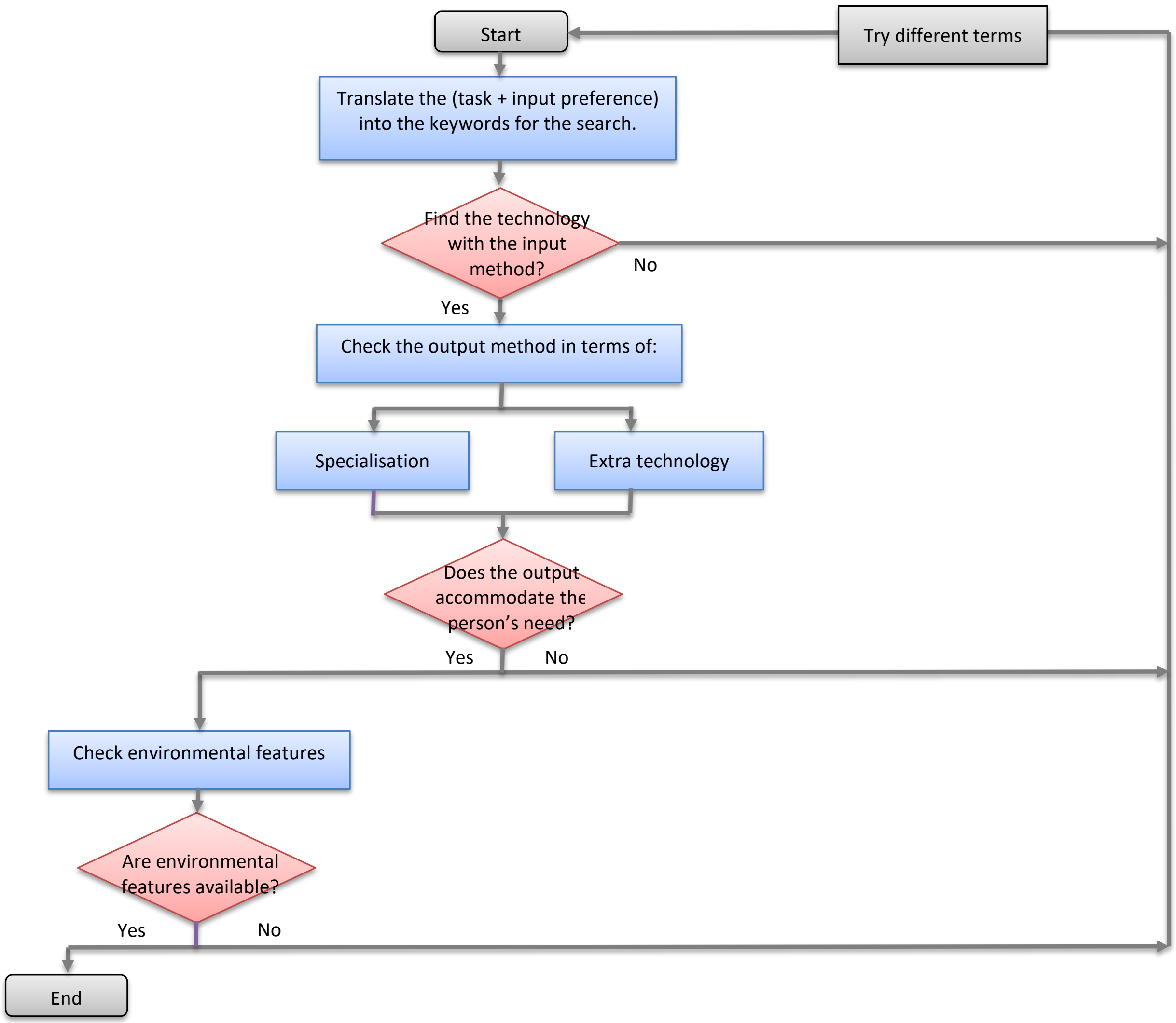
Consider the application of the framework for a past case or a person you know, and answer the following questions:

4. Do you believe that the search tool provides practical steps to find an appropriate mainstream technology by considering the important technology features?
5. In your opinion, does the mainstream technology selection framework include the important concepts (task, person, environment and technology) for conducting an appropriate technology selection? Why?
6. Do you think that a concept (some concepts) that is (are) important for conducting an appropriate technology selection has (have) not been considered by the framework? If so, what is (are) this (these) concept(s)?
7. Do you believe that the framework is useful for selecting an appropriate technology for a person with a physical disability? Why?
8. Overall, is the framework valuable? If so, why or how?

AC.1 Decision tool



AC.2 Search tool



AC.3 Interview 1 and Interview 2

Interview 1: Assessment of needs and abilities

Name ________________________________ Code ________________________________

Age _________________________________ Contact details ________________________

Date of interview (1) ___________________

Type of disability ____

Brief description ____

____

____

1. Tasks (activities)

Can you suggest at least THREE activities for which you wish you have technology for?

I wish there is a technology helps me do:

____

____

____

Ignore the following question in case the participant answered question 1:

What are the kinds of activities that family members or carers do for you?

____

____

____

Choose one task from question 1 or 2 to complete the rest of the interview.

The chosen task is: ____

Can you break the task to subtasks by dividing the task into steps?

Step1: _______________

Step2: _______________

.
.
.
Step N: ______________

Is your disability from birth, or was it acquired at a later stage in your life?

____

____

Is this task something that you used to do before having the disability (in case the disability was acquired at a later stage in life)?

____

____

Analysis of current situation:

How do you currently accomplish the task?

____

____

____

What are the advantages of the currently used method?

____

____

____

What are the disadvantages of the currently used method?

____

____

____

Have you ever used any technology to help you do the task?

____

____

____

> Ask the following question in case the participant mentioned non-technological method in question 6.1:

Have you had any problems with technology that supported you in the past?

____

____

____

2. Personal information

Capabilities

How do you rate and describe your capabilities, using the following levels on the scale?

How do you rate and describe your ability in regards to the following interaction capabilities?

* Interaction capabilities scale: 0 (none), 1 (poor), 2 (fair), 3 (good), 4 (very good), 5 (excellent)

Capabilities	Rate	Description
Vision	……....	……………………………….………
Hearing	……....	…………………………………
Somatic (the ability to sense touch)	……....	…………………………………
Audio (speech)	……....	…………………………………
Head control	……....	…………………………………
Shoulder control	……....	…………………………………
Arm control	……....	…………………………………
Elbow control	……....	…………………………………
Hand control	……....	…………………………………
Finger control	……....	…………………………………
Knee control	……....	…………………………………
Foot control	……....	…………………………………

Do you prefer specific methods to interact with the technology?

____

____

____

How does the use of the technology affect your self-identity?

____

____

____

____

3. Environment

Describe the environment where you intend to perform the activity.

____

____

How do you want to interact with the technology (sitting or on the go)?

____

____

____

How long/often do you expect to use the technology?

____

____

____

How do the attitudes of people around you affect the use of the technology?

____

____

____

Do you prefer the technology to be visible or inconspicuous?

____

Do you have any special requirements regarding the following:

Technology device’s size ________________________________

Technology device’s weight ______________________________

Technology’s device’s features ___________________________

Other ____

____

Additional comments

____

____

____

Interview (2): Evaluation of technology effectiveness

Name ______________________________ Code ______________________________

Technology device ______________________________________

Date of evaluation _______________________________________

How long have you had the technology? _____________________

Frequency of use of the device (___ times per day, per week, per month)

1. The goal (needs)

What was your goal?

____

Did the technology help you achieve your goal? If so, how?

____

____

____

How effective was the technology (the degree to which the technology met your needs)?

____

____

____

How did the technology help you overcome your previous difficulties?

____

____

____

Do you still need help from family members or carers to do any part of the task?

How would you compare the previous method with the use of the technology in doing the same task?

Did you use the technology for other tasks or activities? If so, what were these activities?

2. The technology

What technology did you use?

What task were you doing when using the technology?

What were the advantages of the technology?

How easy was it to use the technology?

How comfortable was your technology (physically and emotionally)?

Did you experience any difficulties in using the technology? If so, what were these difficulties?

How did the use of the technology meet your expectations?

How satisfied were you with the following:

- Physical features (e.g. size, weight)

- External design (e.g. colour, visibility)

- Technical features (e.g. battery, screen brightness)

___

___

- Privacy (e.g. sound)

___

___

3. The environment

Did you use the technology in the environment where you intended to use it? If not, why did you not use it?

___

___

___

How did the technology overcome the environmental barriers (light, sound)?

___

___

___

How did the opinions of people around you affect your continued use of the technology?

___

___

___

Would you continue using the technology in the future? Why or why not?

___

___

___

___

Appendix D: The Arabic Version of the Interview 1 and Interview 2

المقابلة الأولى

الاسم الرمز

العمر وسيلة الاتصال

تاريخ المقابلة

نوع الاعاقة

وصف مختصر للحالة

المهمة (النشاط)

1. هل تستطيع أن تسرد ثلاث أنشطة تود لو أن لديك تكنولوجيا تساعدك على القيام بها؟
2. ماهي الأنشطة التي يساعدك أفراد العائلة أو الشخص الذي يعتني بك للقيام بها؟
3. كيف تقوم بهذا النشاط حالياً؟
4. ماهي محاسن الطريقة الحالية للقيام بهذا النشاط؟
5. ماهي مساوئ الطريقة الحالية للقيام بهذا النشاط؟
6. هل تستخدم أي تكنولوجيا للقيام بهذا النشاط؟
7. هل كنت تواجه مشاكل مع أي تكنولوجيا كنت تستخدمها في السابق؟

المعلومات الشخصية

القدرات

1. كيف تقيم وتصف قدراتك التفاعلية التالية:

القدرات	المعدل	الوصف
البصر		
السمع		
الاحساس		
النطق		

		التحكم بالرأس
		التحكم بالأكتاف
		التحكم بالذراع
		التحكم بالكوع
		التحكم باليد
		التحكم بالأصابع
		التحكم بالركبة
		التحكم بالقدم

2. هل تفضل طريقة معينة للتفاعل مع التكنولوجيا؟

البيئة

1. أين تنوي استخدام التكنولوجيا؟
2. في أي وضع تفضل استخدام التكنولوجيا؟
3. كم المدة المتوقعة لاستخدام التكنولوجيا؟
4. كيف تؤثر توجهات الناس من حولك على استخدامك للتكنولوجيا؟
5. هل تفضل أن تكون التكنولوجيا مرئية أم غير ظاهرة؟
6. هل لديك متطلبات خاصة بالنسبة لي:
   - حجم التكنولوجيا
   - وزن التكنولوجيا
   - مميزات أو خصائص التكنولوجيا
   - أخرى

هل تحب اضافة أي شيء؟

المقابلة الثانية

الاسم　　　　　　　　　　　　الرمز

التكنولوجيا المستخدمة

تاريخ التقييم

مدة استخدام التكنولوجيا

عدد مرات استخدام التكنولوجيا

الهدف (الاحتياج)

1. ماذا كان هدفك من استخدام التكنولوجيا؟
2. هل ساعدتك التكنولوجيا على تحقيق الهدف؟
3. الى أي مدى كانت التكنولوجيا مساعدة لك لتحقيق هدفك؟
4. كيف تغلبت التكنولوجيا على الصعوبات السابقة؟
5. هل لازلت تحتاج مساعدة من أحد في أي جزء من المهمة التي تريد انجازها؟
6. كيف تقارن طريقتك السابقة لانجاز المهمة باستخدام التكنولوجيا لانجاز نفس المهمة؟
7. هل استخدمت التكنولوجيا لانجاز مهام أخرى؟

التكنولوجيا

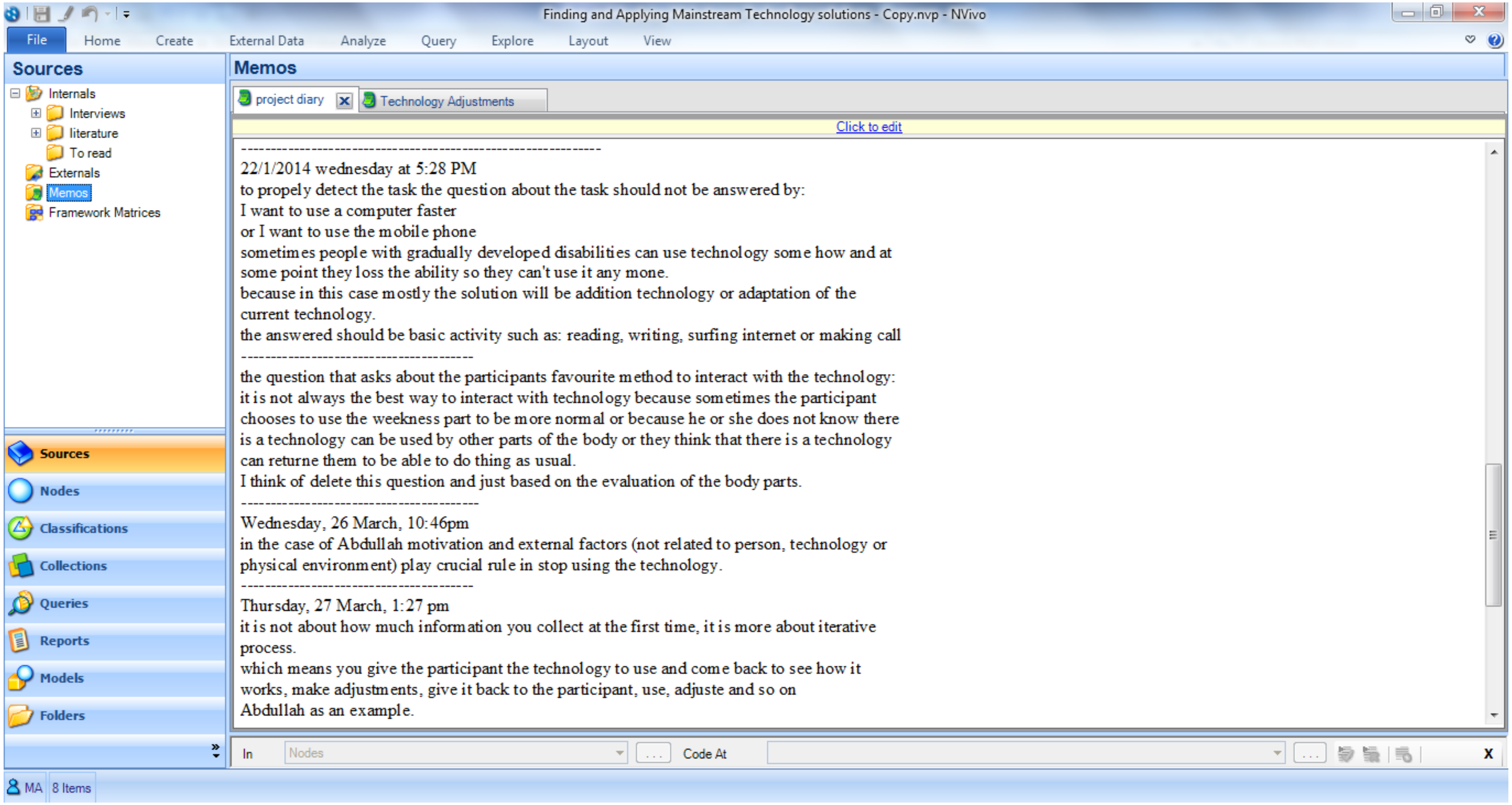
1. ماهي التكنولوجيا التي استخدمتها؟
2. ماهي المهمة التي استخدمت التكنولوجيا لانجازها؟
3. ما مدى سهولة استخدام التكنولوجيا؟
4. ما مدى راحتك عند استخدام التكنولوجيا من الناحية النفسية والجسدية؟
5. هل واجهتك أي صعوبات خلال استخدام التكنولوجيا؟
6. هل وافقت التكنولوجيا توقعاتك؟
7. الى أي مدى أنت راض عن:
   - الخصائص الفيزيائية (الحجم والوزن)
   - التصميم الخارجي (اللون، كون التكنولوجيا مرئية)
   - الخصائص التقنية (البطارية، وضوح الشاشة)
   - الخصوصية (الصوت)

البيئة

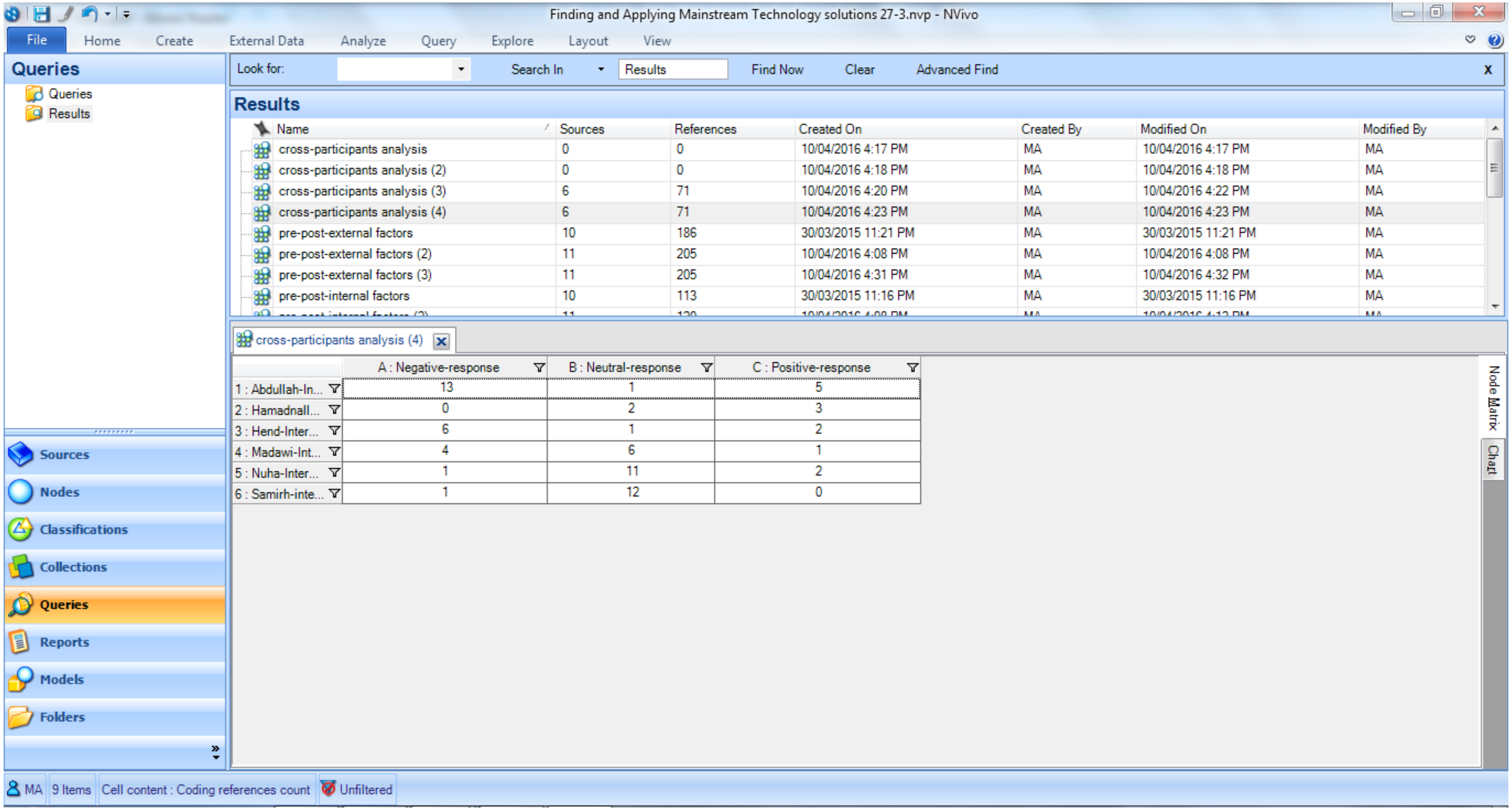
1. هل استخدمت التكنولوجيا في نفس البيئة المرادة؟ اذا كان الجواب بـ لا لماذا؟
2. كيف تغلبت التكنولوجيا على الصعوبات البيئية مثل الصوت والضوء؟
3. كيف أثرت أراء الناس من حولك على استمرارية استخدامك للتكنولوجيا؟

هل ستستمر باستخدام التكنولوجيا في المستقبل؟ لماذا؟

Appendix E: Sample of Nvivo Research Memos



Appendix F: Sample of Nvivo Matrix



Appendix G: Sample of interviews translation (Arabic to English)

English	Arabic
Case (4) – The First Interview The Disabled: I will also help you more, with respect to reading so I wouldn’t forget, I used to find… what do they call it? That mobile unit… what do they call it? The mobile unit! The one they use for the Holy Quran! The Researcher: The Electronic Quran reader, that works by touching? The Disabled: No, No. It’s like glasses or lens that enlarge the writing The Researcher: Oh alright, I understand now what you mean. It’s the magnifying lens that you place over the Holy Quran to enlarge the written text for you The Disabled: Yes, that’s exactly right as the writing in some books can be extremely small The Researcher: It seems that you enjoy reading?	الحالة (4): المقابلة الأولى المعاق: وبعدين كمان أساعدك بحاجة، بالنسبة للقراءة عشان بعدين ما أنسى، كنت متعود اجد ....شنو يسموها؟ هذي المتحركة.... بيسموها ايش؟ المتحركة! اللي بيستخدموها للمصحف! الباحث: المصحف الالكتروني اللي باللمس؟ المعاق: لا لا هو عبارة عن نظارة أو عدسة تكبر الكلمات. الباحث: أيوه فهمتك العدسة اللي بتستخدمها عن طريق وضعها فوق المصحف لتكبر لك النص المكتوب.ً المعاق: أيوه بالضبط لأن بعض الكتب تكون دقيقة جدا الباحث: شكلك تحب القراءة؟ المعاق: نعم الباحث: هذه نقطة مهمة إذن المشكلة عندك الآن هي أن النصوص في الكتب صغيرة. المعاق: نعم بعض النصوص تكون دقيقة جداً لأنه كان عشرين مجلد واختصر في ثلاثة مجلدات فأصبح الخطً صغير جداً كتب التفسير والمجلدات المختصرة مثل كتاب الامام الذهبي (سير أعلام

The Disabled: Yes

The Researcher: In that case, this is an important point. The problem for you then is that the writing used in books is small

The Disabled: Yes. Some texts can be extremely small, especially the books of Tafseer [the explanation of the meaning of Quranic text] and the summarised works like the book of the Imam Al-Dhahabi (The Lives of Noble Figures) where the writing is extremely small because this piece of work was originally twenty volumes and then it was summarised in three volumes only, thus the writing became small

The Researcher: Do you wear reading glasses?

The Disabled: No, No. I read normally

The Researcher: If we focus a little bit on the reading part, how do you currently read?

The Disabled: I sit normally, either on the bed or on a chair, the book being in front of me and then I flip the Holy Quran pages with this hand; in this situation I don't need anyone

النبلاء) كتابته دقيقة جدا.

الباحث: هل تلبس نظارة للقراءة؟

المعاق: لالا، أقرأ بشكل عادي

الباحث: لو ركزنا قليلا على جزئية القراءةً، أنت الان كيف تقرأ؟

المعاق: بأجلس عادي إما على السرير أو على كرسي ويكون الكتاب أمامي وأقلب المصحف بيدي هذي، في هذا الوضع لا أحتاج أحد.

الباحث: وتقلب الصفحات بشكل عادي؟

المعاق: نعم أقلبها بشكل طبيعي.

الباحث: حسنا، ماهي الجزئية أثناء القراءة التي تحتاج فيها الى مساعدة من أحدً؟

المعاق: احتاج الى شخص يحضر لي الكتاب ويضعه أمامي في وضع قريب.

الباحث: ما هو الشيء الذي ترتاح له وتفضله في وضعك الحالي مع القراءة؟

المعاق: أنا مرتاح جداً في طريقة الجلوس ما عندي أي مشكلة وأستطيع أن أحفظ وأراجع حفظي أيضاً

الباحث: ماهي الصعوبات في الطريقة الحالية؟ هل هناك شيء تتمنى وجود تكنولوجيا لتسهيله؟

المعاق: المشكلة الوحيدة هي أن بعض الكتب خطها صغير جدا هذا أهم شيء و أيضاً أحياناً أريد أن

The Researcher: And do you flip the pages the normal way? The Disabled: Yes, I flip them naturally The Researcher: Alright then. During the reading, which part requires you to ask for someone's assistance? The Disabled: I need someone to bring me the book and place it very close in front of me The Researcher: What is the thing that you feel comfortable towards and prefer it in your current reading situation? The Disabled: I am extremely comfortable in the seating position. I don't have any problem; I can memorise and revise what I memorised too The Researcher: what are the challenges you face in the current technique? Is there anything that you wish a related technology exists to facilitate it? The Disabled: The only issue is that some books have very small fonts; this is the most important thing. Also, sometimes, I want to open two books at the same time, such as the Holy Quran and the Tafseer in	أفتح كتابينً في نفس الوقت مثل القران والتفسير للرجوع الى معاني الكلمات وهذا أيضا صعب. الباحث: هل سبق واستخدمت أي طريقة لمساعدتك في القراءة، مثل المكبر الذي أشرت اليه قبل قليل؟ المعاق: أبداً لم أستخدم أي شيء.

order to go back to the meanings of the words, and that is also hard The Researcher: Have you ever used any method to help you with reading, such as the magnifier you pointed to just before? The Disabled: I never used anything NATIONAL ACCREDITATION AUTHORITY FOR TRANSLATORS AND INTERPRETERS NAATI No. [illegible] RANIA SOUFI TRANSLATOR ARABIC <-> ENGLISH Rania ©	

English	Arabic
Case (6) - The Second Interview The Researcher: I want now to ask you about your expectations regarding the voice recognition software that you used The Disabled: The software exceeded all my expectations. A British lady, whom I met years ago, told me that there is a software that enables me to speak and then it would type what I say. She advised me to try using it. I did not know the name of the software at the time and did not ask her for more information. When I discovered more about it through you, I realised that this was the software she has indicated The Researcher: I want to ask about the extent of your satisfaction with the software's features, such as not having to press the record icon and also being able to use the resulting text as a written email or a tweet on tweeter? The Disabled: Frankly, there are particular things that pleased me. First, I found the software that can help me and second, I found a researcher who is interested in people with special needs, who wants to help them, made them the heart of her research and is using the	الحالة (6): المقابلة الثانية الباحث: الآن أريد أن أسألك عن توقعاتك بالنسبة لبرنامج التعرف على الصوت الذي استخدمتيه؟ المعاق: البرنامج تجاوز كل توقعاتي، سبق وقالت لي بريطانية قابلتها قبل سنوات أن هناك برنامج أنا أتكلم وهو يكتب الكلام الذي أقوله حاولي تستخدمينه. أنا ما عرفت اسم البرنامج ولم أخذ منها معلومات ويوم اكتشفته معاك أكثر عرفت أنه هذا هو البرنامج الذي تقصده. الباحث: أريد أن أسألك عن مدى رضاك عن مميزات البرنامج، مثل عدم ضرورة الاستمرار بالضغط على أيقونة التسجيل وأيضا إمكانية استخدام النص الناتج كرسالة نصية أو تغريدة في تونر؟ً المعاق: بصراحة هناك أشياء محددة أسعدتني. أولاً وجدت باحثةً مهتمة بذوي الاحتياجات الخاصة وتريد مساعدتهم وهذا هو صلب بحثها وتستغل التقنية في مساعدة الآخرين وهذا شيء رائع. وثانياً وجدت البرنامج الذي يمكن أن يساعدني. وإذا شكرتيني لأني ساعدتك في بحثك فأنا أشكرك لأنك أعطيتيني هذه الفرصة وجعلتيني أسعد نفسي وأسعد غيري ممن لديهم نفس المشكلة. الباحث: هل افتقدتي شيء في البرنامج وتمنيتي لو أن البرنامج يحتوي على هذه الميزة؟ المعاق: كنت أتمنى لو أن البرنامج ينطق الكلام بعد تحويله الى نص بصوت مسموع حتى أتأكد أنه كتبها بالشكل الصحيح. الباحث: ذكرتي لي أنك ترغبين باستخدام البرنامج داخل المنزل هل استخدمتيه في نفس البيئة؟ أو في

technology to help others, this is simply wonderful.

And if you want to thank me for helping you with your research, I in turn want to thank you for giving me this opportunity and for allowing me to be pleased with myself and to please others who suffer from the same problem

The Researcher: Did you lack anything in the software and wished that it had that feature?

The Disabled: I wish that the software would read the words, in an audible voice, after converting them into a written text in order to make sure that it has written them correctly

The Researcher: You mentioned to me that you wanted to use the software at home. Have you used it in a similar environment? Or in other environments?

The Disabled: I used it at home, at the university and in the car; nearly everywhere

The Researcher: So you did not have any difficulty using the software anywhere!

بيئات أخرى؟

المعاق: استخدمته داخل المنزل وفي الجامعة والسيارة في كل مكان تقريباً

الباحث: اذن لم تواجهي أي صعوبة في استخدام البرنامج في أي مكان!

المعاق: لا أبدا وحتى لو كان الشيء الذي استخدمه واضح أنه مخصص للمعاقين فأنا لا أستحي ولكن هذا البرنامج يستخدمه كل الناس كما أتوقع.

الباحث: وهل هذا الشيء ساعدك؟

المعاق: نعم

الباحث: أريد أن أسألك عن أراء الناس من حولك حول البرنامج؟ وهل أراءهم تؤثر على استخدامك للبرنامج؟

المعاق : لابد أن يستخدموا لبرنامج أولا كما جربته أنا حتى يتمكنوا من إعطاء رأيهم، وحتى لو انتقدوا البرنامج فشخصيتي أساسا أنني لا أنقاد لأراء الآخرين. الشيء الذي اقتنعت به حتى لو واجهت أراء ضد أفكاري فلا ألتفتً لها

The Disabled: No, never. Even if the thing I am using is clearly designed for the disabled, I do not feel ashamed using it, but I believe this software is being used by everyone The Researcher: Did this thing assist you? The Disabled: Yes The Researcher: I want to ask you about the opinions of people around you regarding this software? And do their opinions affect your use of the software? The Disabled: It is imperative that they use the software first, like I did, in order to have an opinion. Even if they criticise the software, basically, I do not let the opinions of others dictate my actions; that’s my personality. If I’m convinced with something, I don’t pay any attention to others opinions even if they are against my views	

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