A METHOD TO IMPROVE THE COMMUNICATION BETWEEN INFORMATION TECHNOLOGY AND HEALTHCARE PROFESSIONALS DURING MOBILE HEALTHCARE APPLICATION DEVELOPMENT PROCESS

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ABSTRACT

A METHOD TO IMPROVE THE COMMUNICATION BETWEEN INFORMATION TECHNOLOGY AND HEALTHCARE PROFESSIONALS DURING MOBILE HEALTHCARE APPLICATION DEVELOPMENT PROCESS

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Mobile healthcare applications constitute alternative tools to increase service quality and effectiveness, decrease time spent on service presentation and therefore they are reforming and changing healthcare service delivery. Achievement in this reform depends on the effectiveness of the developed mobile healthcare applications. Development of effective mobile healthcare applications, on the other hand, requires detailed domain knowledge which normally IT professionals do not have. To provide a solution to this problem, IT people collaborate with healthcare professionals but usually communication problems emerge between them. To reduce this communication gap, IT professionals use UML representations which are rather complex for healthcare professionals. Moreover UML needs to be transformed for mobile agents that make it more complicated. Therefore a simpler and innovative representation method for mobile healthcare application development process is needed. For this reason, in this study, we proposed a new method which is expected to meet this need and is simpler than UML. To test the proposed method a strong research process was implemented starting from evolution of the method and ending with an experimental study. 105 participants are included in this research and it is shown that the proposed method constitutes a viable alternative for both IT and healthcare field and deserves further studying.

Key Words: mobile healthcare applications, communication gap, effective development process.

ÖZ

MOBİL SAĞLIK UYGULAMASI GELİŞTİRME SÜRECİNDE SAĞLIK VE BİLGİ TEKNOLOJİLERİ UZMANLARI ARASINDAKİ İLETİŞİMİ GELİŞTİRMEYE YÖNELİK BİR YÖNTEM

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Mobil sağlık uygulamaları sağlık hizmet kalitesini ve etkinliği artıran, sağlık hizmeti sunum süresini kısaltan; dolayısı ile sağlık hizmeti sunumunu iyileştiren ve değiştiren alternatif araçlar olarak görülmektedir. Bu yeniden şekillendirme ve değişim sürecinin başarıya ulaşması geliştirilen mobil sağlık uygulamalarının etkinliğine bağlıdır. Fakat etkili mobil sağlık uygulamaları geliştirmek BT uzmanlarının sahip olmadığı ayrıntılı alan bilgisi gerektirmektedir. Bu sorunu çözmek için BT çalışanları sağlık uzmanlarından destek almakta fakat bu süreçte çoğu zaman BT ve sağlık uzmanları arasında iletişim problemi ortaya çıkmaktadır. Bu iletişim problemini azaltmak için BT sektörü, aslında sağlık uzmanları için karışık olan UML gösterimlerini kullanmaktadır. Ayrıca UML gösterimlerinin mobil ortamlara göre değiştirilmesi gerekliliği bu gösterimleri daha da karmaşık hale getirmektedir. Bundan dolayı mobil sağlık uygulamaları geliştirme süreci etkinliği için daha basit ve daha yenilikçi gösterim yöntemleri gereklidir. Bu sebeple, bu çalışmada, sözkonusu ihtiyacı karşılaması beklenen ve UML gösterimlerinden daha basit olduğu iddia edilen bir gösterim yöntemi önerilmiştir. Önerilen yöntemi test etmek için, yöntemin geliştirilmesinden başlayıp deneysel çalışma ile sonlanan güçlü bir araştırma süreci uygulanmıştır. Bu test için 105 katılımcı ile çalışma yapılmış ve sonuçlar önerilen yöntemin hem BT hem de sağlık alanları için alternatif bir yöntem olduğunu ve üzerine çalışılmayı hakettiğini göstermiştir.

Anahtar Kelimeler: mobil sağlık uygulamaları, iletişim problemi, etkili geliştirme süreci

To My Family

and

My Love

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LIST OF ABBREVIATIONS AND TERMS

AD: Activity Diagram

BT: Bilgi Teknolojileri

Domain Professional: The person who is an expert in a specific domain like healthcare, aerospace, procurement etc. In this thesis, both the terms “Domain Professional” and “Domain Expert” have been used.

HCI: Human Computer Interaction

Healthcare Professional: The person who is an expert in a specific health domain. In this thesis, both the terms “Healthcare Professional” and “Healthcare Expert” have been used.

ICT: Information and Communication Technology

IS: Information Systems

IT: Information Technology

IT Professional: The person who is an expert in information technology field. In this thesis, both the terms “IT Professional” and “IT Expert” have been used.

MAFR: Mobile Application Flow Representation

SLD: Speech and Language Disorder

UML: Unified Modeling Language

CHAPTER 1

INTRODUCTION

1.1 Motivation and Problem Statement

Technology has become an important phenomenon that plays a key role for shaping both our daily and professional lives. Recent technological developments, on the other hand, have directed us to mobile technologies and have led to a renewed interest in using them for different fields like consumer services, retail industry or banking. Although it was formerly considered to be less effective than computer technologies due to limited battery life, and restricted computational capability, recent developments in mobile agents have made them indispensable components of our lives. Even though it is too radical, it wouldn't be wrong to say that "if you haven't tried to look for a mobile solution yet, then you haven't considered all solutions" (Postings, 2012).

Healthcare is one of the fields that mobile technologies embrace tightly. The annual growth rate of the market for mobile healthcare applications is 61% and the market is estimated to catch $26 billion income by 2017 (Research2guidance, 2013). There are different reasons why mobile technologies are quickly accepted in the healthcare field. First of all, since human life is more important than anything, there is an increasing request for healthcare delivery to provide better services, to keep the costs minimum and at the same time to increase the quality. This demand has oriented healthcare providers to use different methods and technologies than traditional ones, which are not sufficient any more. Consequently, they have decided to choose mobile technologies because they are ubiquitous and provide cost and time effectiveness. The global technology industry leader of Ernst & Young has stated "*Smart mobile devices and applications, working in concert with cloud computing, social networking and big data analytics, will be at the core of global health care transformation. These transformative technologies will continue to lead with ways to help rein in cost, broaden access, change behaviors and improve outcomes*" (Hayek, 2012, p.3). Secondly, mobile agents have "all in one" feature meaning that they can handle complicated health information. Complex health information can be functionalized by using mobile agents via video, text, audio and photo at the same time (Loo, 2009). With these broad features, they have the potential to deliver diverse, alternative and richer healthcare services. Thirdly, mobile agents increase the interaction and doctor-patient rapport. Mobile health technologies provide data that are more detailed, improve doctor-patient relationship and increase patient

engagement (Scher, 2011). For example, patients with diabetes can track their insulin records and send them to their doctors and be replied via mobile healthcare applications. Finally, mobile agents can guide patients about their health conditions. Patients constantly seek for assistance and mobile health applications can provide this support. The ubiquity and real time access feature of mobile agents permit patients self-tracking and reach their doctors to share health related information (Mannino, 2012).

There are various other reasons why the healthcare field has been adopting mobile technologies so rapidly and enthusiastically. However, whether the healthcare sector has caught the anticipated quality and the effectiveness by integrating mobile healthcare applications is still a question. Lately, different studies have examined the effectiveness of different weight loss mobile applications and stated that none of them was effective (Sorte & Spira, 2011). IT shareholders have seen this great potential in mobile health and so they have directly jumped into the action without considering the natural complexity of the healthcare sector. However, the sector doesn't need millions of mobile healthcare applications, it does need effective mobile healthcare applications which improve the quality of service delivery and decrease the costs at the same time meet the demands of both doctors and patients. One of the significant factors to catch the success in developing effective and high quality mobile healthcare applications is to involve the healthcare professionals in the development process. The context of mobile healthcare applications is not trustworthy because they are created by non-professionals mostly (O'Neill, 2012). Developing health related applications requires expert judgment. Scher (2013) explained the reasons why mobile healthcare applications fail as lack of clinical involvement, not knowing the healthcare landscape and not building regulatory specifications. Moreover, Franko (2013) stated that involvement of healthcare professionals in development is of utmost importance for ensuring safety and risk mitigation of providers.

Although the solution for developing effective mobile healthcare apps, i.e. involvement of healthcare professionals in the development process, appears to be obvious, this gives rise to a new problem, and it is a crucial one: communication gap between IT and healthcare professionals. Health domain is as difficult for IT professionals as IT domain is for healthcare professionals. Since it is complex to implement successful healthcare IT systems, effective team relationships should be created between IT and healthcare professionals (Wu, Chen & Greenes, 2009). The effectiveness of this partnership is directly related to the effectiveness of the healthcare IT system. Efficient collaboration is the primary factor for gaining benefit through IT and healthcare environment (Feeny, 1998). Moreover, to fortify this relationship between IT and healthcare professionals, IT experts are required to be involved and comprehend the health domain (Bakker, 2002). A common ground is essential to achieve this connection but how this common ground will be created has been a question for a while. IT field has created a solution to communicate with domain experts. They use different modeling and representation guidelines, which in fact should still be improved because existing guidelines don't meet the need of specific domains like healthcare. Moreover, they are heavyweight tools to be understood by domain experts (Felfernig, 2000).

One of the modeling methods, Unified Modeling Language (UML), is the guideline most commonly used by IT professionals. It is the most commonly used modeling language for various projects (Chaurasia, 2011). However, in addition to its complexity, it does not meet the requirements of specific domains like healthcare. UML is not usable for various domains

and its semantics is not clear and consistent (Burton-Jones, 2002). Moreover, Wills (2004) stated that UML is too limited for domain specific languages and it contains just particular types of graphical format. Furthermore, even if it supports requirement elicitation and code development, UML is inadequate for domain specific tasks (Brucker, 2007).

To add more, existing representation guidelines including UML do not meet the need of mobile agents. Although different agent-based representations and guidelines have been developed, none of them has a large context for multi agent systems (Belloni, 2003). Mobile environment has special interaction components and existing representations are not customized for them.

In summary, technology is running towards mobility and different fields have been adopting mobile applications. Healthcare is one of the fields that enthusiastically require mobile solutions to increase effectiveness and quality of service delivery, and decrease costs. However, developing such mobile healthcare applications requires domain knowledge which IT professionals do not naturally have. To handle this situation, healthcare experts are included in the development process, which leads to a new problem: communication gap between IT and healthcare professionals. This is the problem that we have focused on in this study. This problem has been intensively mentioned in the literature but to fortify our assertion, we have conducted a questionnaire with 50 IT professionals and verified the problem. Methodology chapter includes detailed explanation about this questionnaire. In order to overcome this problem, a common understanding should be established. In this research, we propose a new representation guideline that would improve this common gap and we call it Mobile Application Flow Representation (MAFR). Our hypothesis is that by using MAFR, the communication gap between IT and healthcare professionals could be decreased and it would increase the understandability. We have tested this hypothesis through a strong research process including questionnaires, interviews, pilot and experimental study with both IT and healthcare experts.

1.2 Purpose of the Study

The main purpose of this experimental study is to propose an innovative representation guideline (i.e. MAFR) for mobile healthcare application development process, which will help to fill the communication gap between IT and healthcare professionals and substantially meet the representation requirements of mobile environment.

Specifically this study has aimed to;

- Provide a more understandable and simpler representation guideline for IT and healthcare professionals so that they can understand each other better during mobile healthcare application development process;
- Ensure a common understanding for people from different domains with the proposed medium;
- Increase the effectiveness of mobile healthcare applications by including healthcare professionals into development process with the proposed MAFR;

- Provide a medium for healthcare professionals so that they can understand the IT domain well and transfer their domain knowledge accordingly.

Data were obtained through pre-questionnaire, experimental study, post-questionnaire and in depth interviews conducted with attendees, IT and Speech and Language Disorder (SLD) experts.

1.3 Significance of the Study

There are different aspects describing the significance of this study and they can be grouped as follows:

- Significance in terms of patients with SLD;
- Significance in terms of healthcare professionals;
- Significance in terms of IT experts;
- Significance in terms of mobile interaction.

The study is important for patients with SLD. Patients with SLD have to go to the therapists regularly and they have to work on the exercises that the therapists give them at home on their own or with the help of their parents. Those exercises include traditional methods mostly with paper-based materials, which can be boring and ultimately lead the patients not to complete the assigned exercises. To prevent such negative effects, computer based systems are used which are replaced by mobile based systems with the changes in technology. However, effective mobile healthcare applications are needed to improve the therapy process. This study proposes a tool to smooth the path for the development of effective mobile healthcare applications.

This study is also important for healthcare professionals. Primarily, they will make use of effective mobile healthcare applications, which will diversify their therapy methods. Secondly, they will express themselves much better to the IT personnel during development process. And lastly, they will use effective mobile healthcare applications as incentives for the exercises of patients.

Moreover, this research is important for IT experts. IT experts have difficulty in expressing themselves to the domain experts because of the difference in the area of expertise. In order to overcome this problem, they used different techniques which are not sufficient and don't satisfy the needs of mobile environment. This study will bring an alternative and much more effective method to the sector; therefore, IT experts will make use of the results.

Finally, this study is important for the mobile interaction field. It will blaze a trail with the proposed MAFR for mobile interaction. Mobile environment has different requirements and features than a computer environment. To meet these requirements an innovative way, like the one proposed in this thesis, is needed. We believe that the proposed method will increase understandability. It is applicable, viable and deserves further studying.

1.4 Research Questions

In this study, we proposed a new representation, i.e. MAFR, for effectiveness and efficiency of mobile healthcare applications development process. We hypothesized that MAFR is much easier to understand than UML representations for both IT and healthcare professionals. Within this framework, the main research question of this study is; does MAFR increase intelligibility during mobile healthcare application development process for IT and healthcare professionals?

Besides the main research question, this study has also addressed the following research questions:

- Is there a communication gap between IT and healthcare professionals during mobile healthcare application development process?
- Do existing guidelines (i.e. UML, ERD etc.) meet the need of the mobile environment and healthcare sector?
- Does proposed MAFR reduce the communication gap between IT and healthcare professionals?
- Could healthcare professionals transfer the domain knowledge to the IT experts by just using MAFR?
- Would MAFR save time for the mobile healthcare application development process?

1.5 Limitations

This study has reached its goals; however, there were some unavoidable limitations during the research process.

Firstly, this study is limited with the data collected from participants via questionnaire, interview and observation. Although they are assumed to provide correct answers and their real opinions, they may have not done so. Furthermore, during the data collection process they may have been affected by external factors. Therefore, the validity of the study is limited with participant and the reliability of the instruments used.

Another limitation of this research is the restricted number of participants. Since the domain is a specific one, it has been hard to find a higher number of domain experts.

Furthermore, only one scenario was used for MAFR modeling. For enhanced reliability, multiple scenarios from different domains could be used.

Finally, this study is limited to only one healthcare domain, SLD, but further domain-specific studies can be conducted to observe and demonstrate usage in different domains.

1.6 Thesis Organization

This thesis consists of 5 main chapters, which are: Introduction, Literature Review, Methodology, Analysis and Result, Discussion and Conclusion.

In the “Introduction” section, the factors leading to perform such a study and motivation elements are explained and the problem is stated. In addition, this chapter includes the purpose and the significance of the study with the research questions. Furthermore, what kind of assumptions was made and what factors have led to limitations are also explained in this chapter.

The “Literature Review” chapter is divided into three parts which explain the domain, SLD, mobile environment related to healthcare field and development process of mobile healthcare applications. These three categories are supported with the literature research and findings are discussed.

The “Methodology” chapter includes research design, data collection procedure, attendees, materials used and research flow. In the methodology chapter two different but related parts of the research are explained in detail through figures, pictures and flow schemas. Finally, data analysis process is reviewed in this chapter.

The “Analysis & Results” chapter covers the analysis of two parts of the study. Furthermore, it includes data analysis and the results from that analysis. This chapter answers the research questions of this study.

Finally the last chapter “Discussions & Conclusion” discusses the results reached in the preceding chapter. The thesis is concluded after suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews published studies from the literature and their critiques, which support or oppose the issues pointed in the context of this thesis.

In the chapter, firstly, Speech and Language Disorder (SLD) is defined, SLD traditional therapy methods are introduced and technology integrated SLD therapies are overviewed. Secondly, mobile healthcare is explained in detail. In this part a brief overview of mobile healthcare concept is given, then mobile technology integrated healthcare services and current situation of mobile healthcare applications are referred and discussed. Afterwards, mobile healthcare applications development process is pointed out with the sub-topics: communication gap between healthcare professionals and IT experts, mobile healthcare applications development guidelines and importance of usability for mobile healthcare applications. Lastly, results from literature are presented.

2.1 Speech and Language Disorder (SLD)

In this part of the study, SLD is defined and different types of SLD are classified. Moreover, current SLD practices methods are discussed and general SLD therapy framework is mentioned. At the last part of this section, how technology has been affecting the SLD practices and how technology facilitates the SLD practices are stated.

2.1.1 About SLD

The essential part of communication, language, is in the center of our lives, which makes it one of the most important concepts of mankind. Language is unique to people and it is a system including communication mediums like sounds, symbols, vocabulary etc. (MoNE, 2007). Language is defined as an organizational systematic of randomly selected signals and orderly selected structures which are used as a means for communication (Brandone et al., 2006). We, as people, get these signals from outside, put them in a set of structure which we have already obtained from our former experiences, and give the meaning accordingly. The definition of Brandone is supported by Owens (1990) by stating that language is a socially agreed system of symbols based on certain arbitrary coded rules. A large and growing body of literature has been investigated in the context of this thesis, which resulted that there is a

broad volume of published studies describing the language as codes or symbols on which people put a meaning by using socially structured and pre-defined rules.

Speech on the other hand, is a way of expressing ourselves by using language as a tool. Speech means transferring our thoughts by harnessing the socially used language and converting them into certain sounds with our related organs so that we can communicate with others (Konrot, 2000). People join different words and lexical pertaining to a very large vocabulary of the possessing language to vocalize the communication, which is exactly the speech. The verbal expression of the language, speech is an action providing the possibility to perceive the thoughts via ears (Altınmakas, 2010).

In summary, the difference between language and speech can be stated as: language is a medium which consists of arbitrary codes and structures and it is unique to society whereas speech is a method to transmit our feelings and thoughts to others by using the language and it is unique to each member of the society.

As to speech and language disorder, in general, it can be defined as any kind of impairment in the language or speech. SLD is having adversity in speech and language due to a specific deficiency (Ellis & Thal, 2008). Furthermore, American Speech Language Hearing Association (ASHA) defines the SLD as a situation of having complication in using or comprehending the speech, writing or symbol systems (Paul, 2001). Supportively, Irish Association of Speech and Language Therapists (IASLT) express it as impairment of somebody in the understanding or expressing him/herself through speech and language (IASLT, 2007).

It should be noted that SLD doesn't necessarily mean not being able to talk at all. Problems like stuttering, slowness in speech, speech anxiety, articulation problems are also kinds of SLD. Therefore, besides not being able to talk at all, people with SLD could also have difficulty in speaking fluently. There are different levels and kinds of SLD. SLD includes categories like articulation disorders, phonological disorder etc. (Bowen, 2011).

Ozcebe & Tuncer (2012) have grouped the sub-categories of SLD as follows:

- **Articulation Disorder**

  An articulation disorder is defined as having difficulty in generating one or more speech sounds (Arnt & Healey, 2001).

- **Phonological Disorder**

  A phonological disorder is a situation of having problems related to arrange the sounds in an order according to the rules of the language (Wertzner, Papp & Galea, 2006).

- **Motor Speech Disorder**

  A motor speech disorder is having difficulty in planning and implementing the motor skills, including apraxia and dysarthria (Pert, 1995).

- **Structural Based Disorder**

  Structural based disorder is caused by prenatal or postnatal traumas alimentation disorders. For example, cleft palate (Ozcebe & Tuncer, 2012).

- **Sensorial Deprivation and Syndrome Comorbidity Disorder**

  Sensorial deprivation and syndrome comorbidity disorder is the result of a deficiency in a sensory. Hearing-impairment or visual impairment is an example of sensorial deprivation and syndrome comorbidity disorder (Ozcebe & Tuncer, 2012).

Ozcebe & Tuncer (2012) have divided SLD into 5 sub-categories; however, MoNE (2007) classified it into 4 sub-categories as:

- Articulation Disorder
- Phonological Disorder
- Stuttering Disorder
- Aphasia Disorder

Bowen (2011), on the other hand, has classified speech sound disorders as follow;

- Articulation Disorder
- Phonological Disorder
- Motor Speech Disorder
- Structurally-based Speech Sound Disorders
- Speech Sound Disorders Associated with Syndromes and Conditions

Crosbie, Holm & Dodd (2005), has grouped the speech disorders as follow:

- Articulation Disorder
- Delayed Phonological Development
- Deviant-consistent Phonological Disorder
- Deviant-inconsistent Phonological Disorder

There are similarities between the categorization expressed by Ozcebe &Tuncer (2012) and those described by MoNE, Bowen and Dood. Although the categorization of Ozcebe & Tuncer seems more detailed, the categorization of other studies is based on the same factors initiating the SLD. There are different classifications in most published research studies, yet, we can generalize it as Ozcebe & Tuncer (2012) did.

These categorizations are made based on the reasons causing the SLD. SLD can emerge from different reasons. It could result from a syndrome, a deprivation, a trauma or an anxiety etc. Even a fear situation during childhood can cause the SLD. These reasons could emerge from physical, emotional or mental situations. SLD may be triggered by illnesses such as autism; developmental disabilities, hearing, neurological or sensory impairment, and behavioral or emotional problems (Boyle, 2011). Altınmakas (2010) also declared that SLD may be revealed by neurological disorder, apoplexy, head trauma, psycho-paresis, autism, face abnormality, environmental factors, uraniscus abnormality, developmental retardation, visual impairment, Down's syndrome or an unidentified reason.

As it is stated in the previous studies, any kind of unexpected or physical anomaly may cause SLD. Therefore, SLD is a very important problem that should be taken into consideration seriously and contrary to thoughts, it is very common in the world. 2-9 % of the children aged between 2 to 7 in the world are reported to have SLD (Kayıran, Şahin & Cure, 2011). This is a huge number, which shouldn't be underestimated. According to statistics, almost 14 million people in the USA suffer from SLD (National Institute on Deafness and Other Communication Disorders, 1995).

In conclusion, SLD is based on having problems in speech or using language due to various certain or uncertain reasons. It is a disease like asthma, diabetes or cancer which should be treated starting from early ages.

2.1.2 SLD Traditional (Current) Therapy Process

As it is stated in the section 1.1, there are different forms of SLD, which needs different therapy methods and specialties. That is why there are different experts specialized in areas like articulation disorder or phonological disorder etc. Experts in the field put great importance on this subject because of the fact that such impairment leads to different unexpected and undesired consequences. For example, SLD problems may affect the subject's personality or social skills negatively (Levitt et al., 1987). Moreover, people with stuttering disorder are likely to have concomitant disorder especially in learning, reading and emotional disabilities (Arndt & Healey, 2001). Schuele (2004), additionally, stated that compared to the peers without having an SLD, a child with speech and language impairments is more likely to have risk for reading disability.

Owing to its importance, the ideal thing to do in the SLD diagnosis is to make the therapy process expedite but not to rush about it. Subject which will be examined regarding the SLD must be examined elaborately and diagnosed accordingly (Ozcebe & Tuncer, 2012). Fallacious deduction in diagnosis could lead severe problems and make the recovery process much longer. Consequently, the more SLD continue the more permanent the malady is going to be (Bishop & Edmunson, 1987).

For all the mentioned reasons, at first, subject with SLD should be evaluated audiologically in detail. With this way, possible hearing loss or audio processing deficiency is eliminated. During the SLD evaluation and therapy process the following processes are followed (MoNE, 2008).

- Examination of previous records
- Standard Tests
- Interviews
- Control Lists
- Observations
- Portfolio Evaluation

Examination of subject's previous records includes the investigation of health records, school records, family records etc. Any kind of previous information is helpful for the diagnosis and enlightens the current situation of the subject. As to standard tests, they are for the evaluation of articulation and phonological development level of the subject (Ozcebe & Tuncer, 2012). Furthermore, during the interview process, information on communication

skills, developmental skills and learning skills are tried to be obtained (MoNE, 2008). Except for the subject, interviews can also be made with related people like family members or school teacher. Control lists on the other hand, give clues about how the subject is perceived by others and provide explanatory knowledge on the social and daily life of the subject. The aim of the observations is to collect data regarding the communication skills of the subject in his/her natural surroundings. Portfolio evaluation, lastly, is used to track the progress of the subject and evaluate the results accordingly. It also guides experts whether the subject failed to respond to the therapy or not, or what the response level is.

These are the steps of the general framework for the traditional SLD therapy process. However, methods used in the therapies can vary from expert to expert, for example, while some therapist use game cards during their therapies, others may use music, and some others use paintings. Methods can change, but the framework is standard.

2.1.3 Technology Integrated SLD Therapies

Health service presentation is changing from doctor-centered care to patient-centered care. Lately, quality improvement and organizational restructuring process of healthcare has primarily focused on the patient centered care (BJs, 2000). Technology on the other hand plays an immense role on this movement, because it provides flexibility for the presentation of health services. Therefore, in healthcare, from hospital information systems to medical device systems, or from health related exercises to health related legal obligations, technology has been intensely used. This broad use of technology, naturally, affects the SLD related practices. With the advancement of technology, starting from 2001, there have been important attempts in SLD therapy interventions (ASHA, 2001). Moreover, Tobolcea&Danubianu (2010) stated that SLD experts have been increasingly interested in using of computer programs in SLD therapies recently.

Lately, it is becoming increasingly difficult to ignore the importance of technology in healthcare and it brings many advantages not just for SLD related activities but almost for all kind of practices in healthcare. First of all, technology enables time-independence for SLD therapies. Technology integrated therapy exercises are available to the subject 7/24 and could be made as frequently as the subject desires (Grawemeyer et al., 2000). Secondly, technology provides cost effectiveness for SLD therapies, especially for the people without any financial support. Especially in rural areas, accessing to speech and language therapy services is expensive due to travel costs and travel time of either service providers or the patients with SLD (Jessiman, 2003). Furthermore, in consequence of increasing costs in face-to-face SLD therapy, technology integrated resources are becoming more popular (Grawemeyer et al., 2000). Finally, technology integrated SLD therapies are more efficient than the traditional methods and contribute to the subject's progress. That is, it increases his/her attention focus, curiosity, interest in activities involved in therapy, develops use of language and social skills, and stimulates affective states and feelings (Tobolcea&Danubianu, 2010). For example, educational computer games have tremendous potential to motivate children to carry out the exercises which indeed are not fun at all (Umanski et al., 2008).

Consequently, integrating technology in SLD therapies is definitely an alternative; cost and time effective, and an efficient way for the productiveness of the therapies. Therefore, they may be integrated into therapy sessions considerably.

2.2 Mobile Healthcare

This part is dominantly focused on mobility in healthcare as well as mobile healthcare applications. First of all, from the literature, different definitions on mobile healthcare are discussed. Then, advantages and disadvantages of integrating mobile applications are argued. Lastly, the current status of mobile healthcare applications is mentioned.

2.2.1 Mobility in Healthcare

Using medical sensors, mobile computing and communication technologies for healthcare delivery is called mobile healthcare (Istepanian & Zhang, 2004). Besides, Vogel et al. (2013) stated that mobile healthcare tries to find a way to catch the dynamics of harnessing mobile devices for miscellaneous aspects of healthcare delivery. It is kind of a transition from computer to mobile in healthcare services and it is an inevitable reflection of advancement in technology to healthcare. However, mobility has not finished the life time of computer based systems but they have brought alternative solutions to the health related problems. Mobility in healthcare can improve patient's satisfaction; enhance the healthcare process and service quality as well as increasing productivity and decreasing administrative costs (Siau & Shen, 2006). Therefore, mobility is a significant factor in healthcare, and it is becoming more important. Numerous published studies in the literature have attempted to explain that mobility will transform healthcare, so it is time to head toward the development of effective mobile healthcare applications.

2.2.2 Integration of Mobile Technologies (Applications) into Healthcare Services

Just like the service providers do in any other field, healthcare providers are also in a great attempt to improve the quality of healthcare delivery, to respond to demands effectively and and efficiently. Accordingly, they make use of the advantages of the technology and hence a strong relationship exists between the improvements of technology and the improvement of healthcare delivery. Advancements in ubiquitous computing and telecom technologies have lead healthcare systems to implement information and communication solutions and services increasingly (Martinez&Tong, 2012). In this respect, healthcare providers firstly have benefited from computer based tools and now from mobile solutions as well.

Starting from entrance to the market mobile solutions have become widespread among people and have been considered as a communication medium whether they are useful in healthcare or not. Integration of mobile technologies in healthcare has different advantages as well as disadvantages. Kaplan (2006) reported that the idea of mobile phones working as a healthcare intervention is neither strongly supported nor refuted (Kaplan, 2006). They increase the patient-doctor communication, provide real time access, and ensure ubiquity. Moreover, they provide better management of diseases, self-control over the diseases, and self-monitoring i.e. they can make the healthcare delivery easier. Mobile applications in healthcare provide better care and services to patients and mobile way of communicating with suppliers and patients (Siau & Shen, 2006). Mobile technologies bring flexibility into healthcare. They have the properties of communication, health information delivery, instant messaging and on demand access. Usage of mobile computing and communication technologies in healthcare is a rapidly growing area of research and practice (Free et al., 2010).

Supportively, patients see great potential in usage of mobile technologies on disease management and they point out that mobile technologies are very useful tools for healthcare (McCann et al., 2009). Several pilot studies have been conducted in developing countries investigating about the usage of mobile application in healthcare. With its ubiquity, mobile phone related applications are a simple, efficient, cheap and sustainable mode of communication for patients (Odigie et al., 2012). In addition, mobile phones provide opportunity for integration of technology and they are promising an innovative strategy for more efficient healthcare delivery in the future (Shet, Ayesha, & Costa, 2011).

However, despite the advantages, the adoption rate of mobile healthcare is relatively low in hospitals (Wu, Li, & Fu, 2011). There should be some reasons for why people are uncommitted to mobile applications. These reasons may include charging problem, small screen size preventing you from quick handling, and platform dependency. Limited features like small screen size, short battery life, limited computing speed, security issues and platform dependency could be a reason why mobile technologies are not so easily accepted in healthcare. Secondly, usability problem is another crucial reason for not being accepted as expected. Owing to small screen size, designs of mobile healthcare applications should be as evident as possible and cumbersome user interfaces should be avoided. Mobile healthcare applications should be easy to interact with and user-friendly (Siau & Shen, 2006). Lastly and importantly, deficiency in tailor-made mobile healthcare applications leads people to refuse them. Healthcare is a specific field and has its own rhythm more than any other field. Therefore, development process of mobile healthcare applications should be different from development process of a standard application. Any model developed for other fields may not be applicable to healthcare environment, so, for the acceptance of mobile healthcare systems, they should be developed according to specific factors like healthcare professional values or mobile computing capabilities (Wu, Wang, & Lin, 2007). For effective application development, healthcare professionals should be included into the development process and a development guidelines specific to healthcare should be implemented to the development process.

To sum up, technology is affecting healthcare delivery abruptly and new trend is going mobile. Using mobile technologies in healthcare has many advantages as well as disadvantages. These shortcomings should be removed as much as possible in order to get the benefit of technology fully by including healthcare professionals starting from the beginning of the application development process. Moreover, development guidelines which are particular to healthcare field should be used so that more user-friendly and effective applications can be implemented into healthcare.

2.2.3 Current Status of Mobile Healthcare Applications

Thousands of mobile healthcare applications have already been displayed in different application markets which means that commercialization phase of mobile healthcare applications has come to the scene. Mobile healthcare applications have become main residents of application markets. It can be called as the mobile revolution in healthcare. Clancy (2011) asserted that over the next four years, mobile healthcare applications will change the way doctors communicate with each other, their work operations and also the way how healthcare organizations interact with patient communities. The vision of Clancy has already started to be true. “Pyramid Research Group” (2011) conducted a report stating

that, more than 200 million mobile health applications were in use by doctors and patients and this number would be tripled in 2012. Another result from that study is that, 70 percent of people worldwide are interested in having access to at least one mobile healthcare application and they are willing to pay for it. Perceived as improving the quality of healthcare services, patients as well as healthcare professionals are embracing mobile healthcare applications so rapidly and willingly. Another report which was prepared by Arthur D. Little Co. (2011) also indicated that mobile health potential value will be $10 billion within the next five years. From these statistics, it shouldn't be so difficult to anticipate that the mobile revolution is already bound to happen. According to recently conducted study "2013-2017 Global Mobile Health Market Report", by 2017 the global market share for mobile healthcare applications will be $26 billion (research2guidance, 2013).

There is a large volume of published studies in the literature giving different numbers about the mobile healthcare applications. For example, according to IDC report (2010), 300.000+ mobile applications were downloaded 10.9 billion times in 2010 and IDC predicts that global downloads will reach 76.9 billion in 2014 and will be worth US$35 billion. Another research group, ABI Research (2011), predicts that there will be 29 billion apps downloaded in 2011, up from 9 billion in 2010. These numbers are a great appetizer for IT companies, so they develop new strategies to add mobile healthcare into their future plans.

What about the obstacles, boundaries, effectiveness and others except for commercialization. Even though there are so many mobile health applications developed so far, outcomes related to use of those applications have been mixed and studies assessing the design and their effectiveness have been limited (Mechael & Sloninsky, 2008). Studies in the literature, researches, and commercial company reports put so much focus on the numbers and statistics and pay insufficient attention to the other factors, which make the mobile healthcare applications useful, efficient and effective. However, healthcare IT is an interdisciplinary field and it is much more complicated than other fields, so, things beyond the statistics or numbers should be considered for the mobile healthcare applications. Mainly, IT experts must understand the healthcare domain to relate it to their own applications and similarly healthcare professionals must understand the IT domain.

2.3 Mobile Healthcare Applications Development Process

In this section, the communication problem which IT and healthcare professionals are faced during development process of mobile healthcare applications is stated and commonly used guidelines to overcome this problem are mentioned. Moreover, the inadequacies of those commonly used guidelines for mobile agents and healthcare domain are discussed. Moreover, the need for an innovative guideline for the sector is mentioned. In this part, usability issues for mobile healthcare applications are also explored.

2.3.1 Communication Gap between Healthcare Professionals and IT Experts

Healthcare IT is an interdisciplinary field and it is much more complicated than other fields, because health issues are critical in terms of patients' lives. This serious domain requires experts from IT and healthcare fields working together. Most of the systems developed for healthcare are inadequate due to the lack of contribution to the work of healthcare professionals (Hardstone et al., 2004). The solution for this situation requires a common

understanding for the included disciplines (Scandurra et al., 2008). Therefore, communication and mutual understanding of IT and healthcare professionals are of vital importance. However, this is the point where the problem emerges. People from different domains – in our case IT and healthcare professionals – have different ways of thinking. Kilov and Sack (2009) stated that communication of experts from different domains is only possible through a joint ontology and creation of this ontology requires a common system of concepts which are applicable and extensible to any specific viewpoint. The question is how these common concepts will be created and how these common concepts will be defined.

'Mobile healthcare IT applications', on the other hand, just the phrase itself includes different domains: Mobile domain, healthcare domain, IT domain and application domain. As it can be inferred, developing a mobile healthcare IT application requires meeting of people from different expertise. Gathering those people is the easy task but, making them work on the same subject and talk the same language may not be that easy. Uniting all those people in a team requires utmost commitment to overcome the communication gap, since the application developers do not have the related healthcare knowledge and the healthcare professionals don't understand the software code unless they are provided a human-readable visualization (Ongenae, 2010). To overcome this problem, a document, which facilitates mutual understanding, should be provided to all those people. There are different kinds of guidelines developed for this purpose, like UML diagrams (see section 2.3.2), but they are complicated for healthcare professionals to understand. If the guidelines are in a very detailed format, the size of the guidelines may become a problem and if they are superficially prepared, they can be vague to interpret (Backere et al., 2010). Besides, healthcare field has different characteristics for which the existing models are insufficient to represent (Baksi, 2009). To fill in the blanks, healthcare sector needs a different way of representation which is as possible as simple and easy to understand not just by IT experts but by healthcare experts as well.

Consequently, there is a communication gap between healthcare professionals and IT experts when it comes to develop an effective mobile healthcare application. To fulfill this gap, people from IT field use different representations like UML. However, because of the unique characteristics of healthcare field, these representations are insufficient to handle this problem. Therefore, an innovative representation is needed for both IT and healthcare fields.

2.3.2 Mobile Applications Development Representations

Visual representations play an effective role in software engineering and hence, IT companies use different visual representations to better express themselves to customers. Playing an important role, graphical representations, especially the one for complicated systems, are better understandable by people and more evident to them (Simons & Wirtz, 2007). However, most commonly used representations are not understood well by domain experts. Representations should ensure that when people from different domains see it, they all understand the same thing.

The most commonly used representation in IT field is UML (Unified Modeling Language) which consists of different graphical notations for the creation of visual representations of software systems. Being a well-known standard in the industry, UML has been adopted dominantly since the presentation of UML included Model Driven Architecture (Nugroho, 2009). There are 14 different diagram types included in UML (Nishadha, 2012).

Recent developments in mobility have heightened the need for customizing UML or other representations in accordance with the mobility context. Already providing alternative methods for this purpose, UML still has different drawbacks (Grassi & Mirandola, 2001). Klein et al. (2001) has also stated that using UML representation for mobile applications is uncommon and limited in extend. Besides, UML doesn't cover the whole software development process. UML is used rarely during maintenance and evolution because manual correction of UML is time consuming and expensive (Sutton & Maletic, 2006). UML and other commonly used representations are insufficient to cover the need of mobile environment. The existing models are inconvenient for modern business processes particularly for mobile systems. Kusek (2007), on the other hand, stated that using UML is for sure very useful in describing different situations, however in particular cases provides limited support for modeling mobility.

Another drawback of UML, which is one of the most important issues for our case, is that it is not well understood by domain experts. UML is not flexible enough to customize and to fit in a particular domain (Henderson, 2005). This is an essential factor for healthcare domain. Healthcare applications, whether they are mobile or not, must be developed with the healthcare professionals' utmost commitment in terms of effectiveness and efficiency. Besides, it would be naive to expect an IT expert to understand the health domain. In addition, this is the point where the role of representation emerges. Representations should be a "domain" model not an IT model. Domain model ensures a commonly used vocabulary and interaction notations which can be understood by anyone included in the software development process (Mehta, 2008). Healthcare professionals have difficulty in understanding UML and other commonly used representations.

As a conclusion, for the effectiveness of software development process, UML has been a dominant tool in IT sector which still has drawbacks especially for domain specific situations. Furthermore, using UML in mobile context has not been advanced yet. There is still room for a great amount of progress in configuring UML for mobile. Domain experts on the other hand have little knowledge about UML which is a complex notation for them. Therefore, a more understandable and more usable representation guideline is needed for specific domains like healthcare.

2.3.3 Mobile Applications Development Representations

In this part, the focus is on usability and human computer interaction. The importance of usability in mobile healthcare systems is discussed.

2.3.3.1 Human Computer Interaction and Usability

Computer systems are now in every field of our lives, which increases the importance of the topic "interaction". People interact with systems and systems are for human use. The concept that the human interacts with any system could be called as human-device interaction, or human-system interaction, or human-application interaction. In ICT world, it is called human computer interaction (HCI). HCI is kind of a dialog and a form of communication through which a degree of understanding could be gained (Booth, 1989). The key term is "Degree of Understanding". How big this degree is ensured by how well the human interacts with the computer. In other words, usability of a computer system is directly proportional to the understandability in a positive manner. We need a bold statement to make on "usability". In

the International Standard Organization 9241-11 catalog (1998) it is said that: “the aim of usability is enabling users to achieve goals and meet needs in a particular context of use with the user performance and satisfaction.” From this definition, we can infer that in addition to the users’ performance and satisfaction, usability enables users to reach the defined goals. Since usability is important to catch the target, the system should be designed as usable and effective as possible.

2.3.3.2 Usability in Mobile Healthcare Systems

According to Nielsen (1993) the usability of systems depends on four characteristics. The system should be;

- Easy to Learn,
- Easy to Remember,
- Pleasant to Use,
- Have Low Error Rate.

Mobile context may require additional factors for usability as mobile systems have unique features that should be taken into account especially for the healthcare systems. First of all, mobile devices have different hardware drawbacks. Even they have the advantage in terms of ubiquity and flexibility; their small screen size, limited battery life, memory and disk capacity are not for the complex healthcare environments (Siau & Shen, 2006). Furthermore, having hardware disadvantages makes them difficult to apply good practices of usability. As a result of the restricted processing power and functionality, usability is an important issue for mobile healthcare applications (Laakko et al., 2008).

In health informatics field, usability has gained such a great importance that acceptance or rejection of a system is directly related to its usability (Tang, 1994). It is quite normal because of the fact that usability problems have direct effect on patient safety (Johnson, 2006). It can be concluded that usability is a life or death matter for mobile healthcare applications, but how usability is ensured for mobile healthcare applications remains as a question. It is becoming gradually difficult to develop usable and tailor-made mobile healthcare applications. Developing goal-oriented applications for healthcare is a challenge due to enormous growth in mobile devices, networks and applications (Yau & Chung, 2007). Mobile healthcare applications must be customized according to patients’ profiles (Shin et al., 2008). On the other hand, without having the knowledge of patient’s and disorder’s characteristics, it is less likely for an IT expert to develop mobile healthcare application which is usable enough.

The best way to ensure usability, quality, effectiveness and efficiency for mobile healthcare applications is to include healthcare professionals in the development process and make them communicate with each other’s languages. However, as it is mentioned earlier, this process creates another problem: communication gap. Communication gap between domain and IT experts results in serious problems for the system design and development and also cause financial loss and customer trust issues (Evans, 2002). Moreover, for any domain specific ICT system, it is a challenge for developers to understand the context of domain and requires knowledge, which can be obtainable from domain participants (Folstad, 2007).

Same thing goes for the healthcare professionals. They have difficulty to understand the models provided to them by IT experts. A common language is needed to overcome this obstacle.

As a result, HCI and usability are one of the two important concepts for mobile healthcare application as they are in other fields and directly affect the acceptance of the application by the target group. However, due to the limited features of mobile agents, usability is a challenge. Moreover, communication gap between IT and domain experts make the situation more complicated. To cope with this matter, a common representation guideline is needed for both IT and domain experts.

2.4 Results from Literature

In Figure 2.1, we have schematically represented the results from the literature to provide an overview picture from the literature on mentioned topics in this chapter.

Results from literature showed that SLD is an important disease which should be treated starting from early ages. There are different treatment methods used by SLD therapists but technology integrated ones are more effective. Therefore technology based applications are needed.

Mobile healthcare applications, in our care mobile SLD applications, are promising technology for both patients and therapists. They are becoming more popular in each day. In fact they are transforming the healthcare delivery. They are great in numbers but the important thing is that they must be effective and efficient for the quality of healthcare service delivery.

For effective mobile healthcare application development, healthcare professionals can be included in the development process. However, there is a communication gap between IT and healthcare professionals. To reduce this gap, IT professionals mostly use UML representations but those representations are not easily understandable by healthcare professionals.

In this research, we propose an innovative representation which we think that it is more intelligible than UML representation and it will meet the need of both IT and healthcare sector in this context. We call it Mobile Application Flow Representation (MAFR).

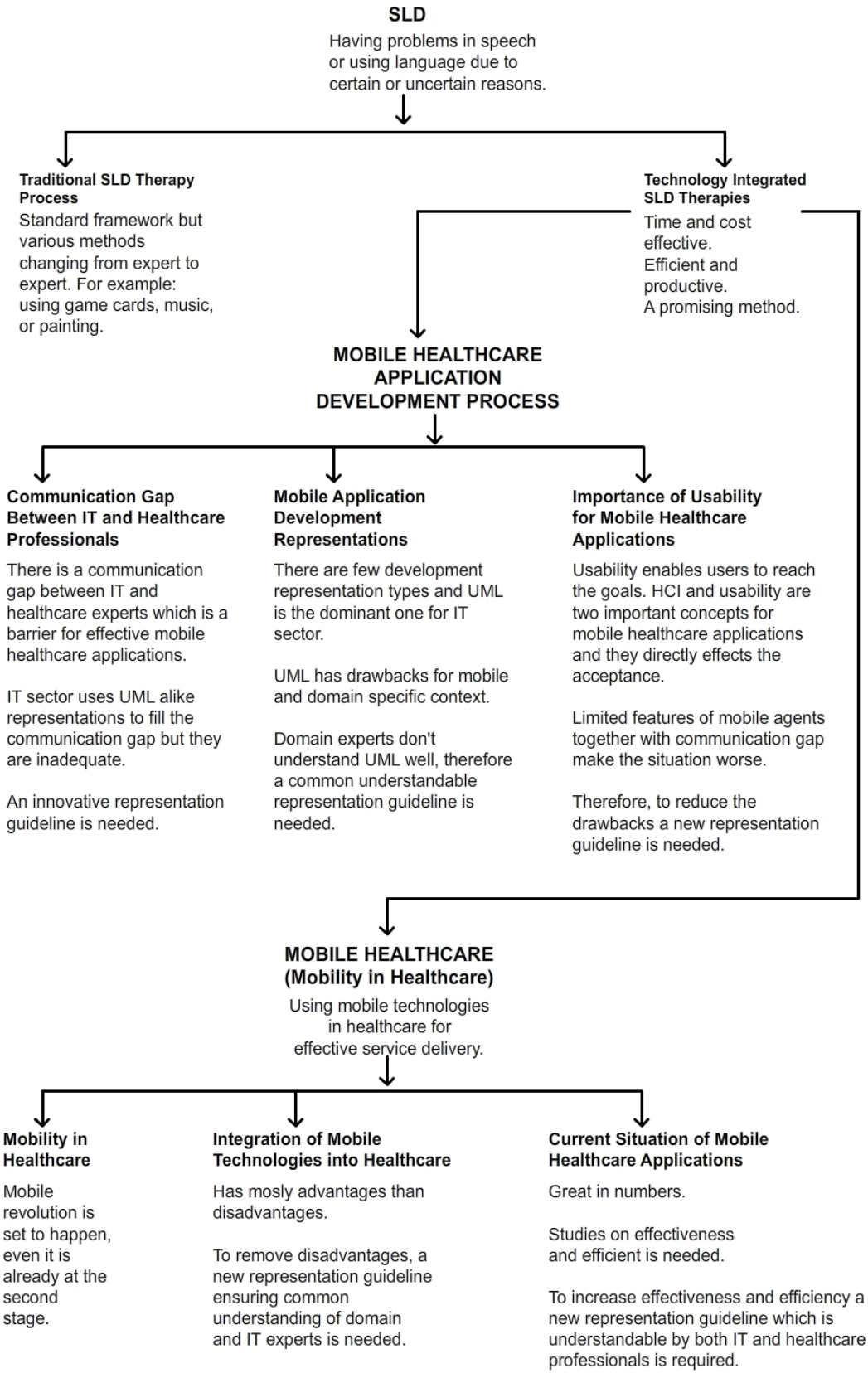


Figure 2.1 Results from Literature

CHAPTER 3

METHODOLOGY

This study aims to propose a tool (MAFR), which is expected to fill the communication gap between IT and healthcare professionals and seek the effectiveness of the proposed MAFR during mobile healthcare application development process.

This chapter, Chapter 3, covers the research methodology of the study. It includes research methods and design as well as population, sampling and used instruments. It also contains data collection procedure and research flow.

3.1 Research Design

In this study, to meet the research questions in depth investigation, multiple tools such as questionnaire, interview, pilot, case and experimental study apparatus have been used to collect data. Such a broad data collection procedure produced both qualitative and quantitative data for the study. Such a mixed method (Johnson et al., 2007) approach tries new strategies and tools to respond to the research questions from different angles and blends qualitative data as well as quantitative data for reaching the answers. In this context, what we implemented to meet the requirements of mixed research design is discussed in the following parts of this chapter. The research procedure is depicted in Figure 3.1.

3.2 Participants

105 participants attended this research study. One of the participants who is an SLD expert with 20 years of experience in the field, has contributed to all stages of this research from evolution of MAFR to experimental study. She is an Assoc. Prof. Dr. at Hacettepe University Speech and Language Education Department.

As to other participants, 90 of them are IT professionals and 14 of them are SLD professionals. 70 of the IT professionals are students at Computer Engineering, Software Engineering, and Information Systems Engineering Departments of Atılım University. 50 of the participants responded to a preliminary questionnaire for defining the problem and this data was used to state the problem. The other 20 IT professionals are from different IT companies at METU Technopolis, Hacettepe Teknopolis and Bilkent Teknopolis.

14 SLD experts are at least 2 year experienced and actively work on the subject. 4 of them from Hacettepe University Audiology Department, other 4 of them work at a private education and rehabilitation center, and 6 of them work as hearing impairment experts.

3.3 Instruments

For data collection of the study, various instruments were used. There are two parts in this study: Evolution of MAFR and Experimental Study (See the Research Flow Section). Therefore, instruments were prepared and used accordingly. At the evolution of MAFR part, first, we have conducted a questionnaire including demographic information, Likert Scale items and open ended questions with IT experts. After that, we have prepared an initial MAFR document including representation elements and an example scenario modeling. Then, we have tested our model with an SLD expert and got feedback in person. Sessions with SLD expert was recorded. Afterwards, we improved our model and prepared a MAFR guide including representation elements and example scenarios. We gave this study guide to 4 SLD experts and conducted a semi-structured interview with them. Finally, a demo mobile healthcare application for patients with SLD was developed.

In the experimental study part, first, participants (IT and SLD experts) were given questionnaires. Then a study guide including scenario of the pilot application and representation elements of MAFR or AD were provided to participants. After that, the defect seeded MAFR of the scenario or defect seeded Activity Diagram (AD) of the scenario were provided to the attendees to find the performances of the participants using MAFR. And finally, a semi-structured interview was conducted with the participants and the interviews were recorded.

There are two types of questionnaires used in the experimental study part. One is for IT experts and the other one is for healthcare professionals. A questionnaire was conducted with IT experts that included demographic information, Likert Scale items on the perception of mobile application development process effectiveness, and open ended questions on current situation and problems that the participants face during application development process. Another survey, different from the one that IT experts answered, was conducted with healthcare professionals. This questionnaire includes demographic information as well as Likert Scale items on current situation for the therapy sessions regarding the involvement of technology, participants' technology experience and technology perception. There is also a yes-no question part on this questionnaire.

Representing the whole population depends on the formula "n = N/(1 + Ne2)", where n = number of respondents, N = population size and e = margin of error. We wanted to use this formula for defining the number of participants that we should use for the questionnaires in both evolution of MAFR and experimental study parts. However, since there is not an exact statistics on the number of SLD or IT experts in Turkey, which means the population size is missing, we couldn't apply the formula. Even the questionnaires were used firstly in this study, we reached as large sample size as we could. Alternatively, to ensure reliability of the questionnaires, we include similar questions repeatedly. Moreover, we compared the results of questionnaires and interviews to validate the results, because validity is limited to reliability of the instruments used and participants' responses.

After the questionnaires were conducted with the participants, they were provided a study guide including a scenario telling about the therapy method that domain experts use in their therapy session for patients with SLD. This study guide also has representation elements of MAFR or AD for participants of the study. Following the study guide, the defected seeded MAFR or AD of the scenario was given to the participants to find the effectiveness of the proposed MAFR tool. Participants were expected to find the defects. Defect detection order and time were recorded for each defect and we measured the performance with two formulas.

Finally, a semi structured interview was conducted with the participants regarding their experience coming from experimental study. This interview includes different questions on MAFR or AD, their experience from the study, and their suggestions to the study.

3.4 Data Collection Procedure

Data collection for this study includes two parts: Evolution of MAFR and Experimental Study. Evolution of MAFR started with the literature review study on mobile application design guidelines and from this review the problem was justified. To strengthen this justification, a questionnaire was conducted to 50 IT professionals to get the problems they have faced during mobile application development process. This questionnaire has been conducted in a class environment including all participants at the same time. After the statement of the problem, the representation elements of MAFR was developed regarding the usability, interface interaction actions and mobile agents unique features. Developed MAFR representations were tested with a 20-year-experienced domain expert and we call this process as a pilot study. Pilot study is the trial study that provides a test environment for the proposed MAFR and it ensures the internal validity. Feedbacks were taken personally from the expert through an intense examination and integrated to the model and MAFR was improved. After this advancement, a case study with 4 experienced therapists was deployed and therapists' views on MAFR were collected via interview. As a result of this case study a demo mobile healthcare application for patients with SLD was developed.

Experimental Study part, on the other hand, was focused on the understandability of MAFR and perception of MAFR from both IT and healthcare professionals sides. To measure this we implemented different defects on MAFR and we defined the participants' performances to find the defect. We also implemented different defects on Activity Diagram (AD), which is one of the most commonly used representation type of UML, to compare the participants' performances. In this part, firstly, a questionnaire was provided to the attendees. There was no time limitation for filling the questionnaire. After the participants took the questionnaire, they were given a study guideline including MAFR or AD elements and pilot scenario which is a game based therapy method. Participants took their time not more than one hour to study the scenario and MAFR or AD elements. Then, previously prepared and defect seeded MAFR or the AD of the given scenario was provided to the participants. While half of the participants were provided a defect seeded AD of the scenario, the other half was provided a defect seeded MAFR. Participants were divided into groups randomly and there was no criterion for group selection. Participants were informed about the number of defects and they were expected to find those defects. While trying to find the defects, they were allowed to look at the study guideline and requested to think aloud. Except from study guideline and defect seeded model, attendees were not provided extra instructional materials. Throughout

this process, defect detection order of each participants, and duration spend by each of them to detect a defect were recorded for the application of Participants' Performance (PP) and Difficulty Level (DF) formulas. Finally, a semi-structured interview was conducted immediately after the experiment and each interview was recorded for the analysis.

For both the evolution of MAFR and experimental study parts, the data was collected in each therapist's or IT professional's workplace. There was no time limitation for questionnaires and interviews, but there was a 1-hour time limitation for the study guideline. In fact none of the participants demanded more time during the experiment. In Figure 3.1 we present the research procedure of this study.

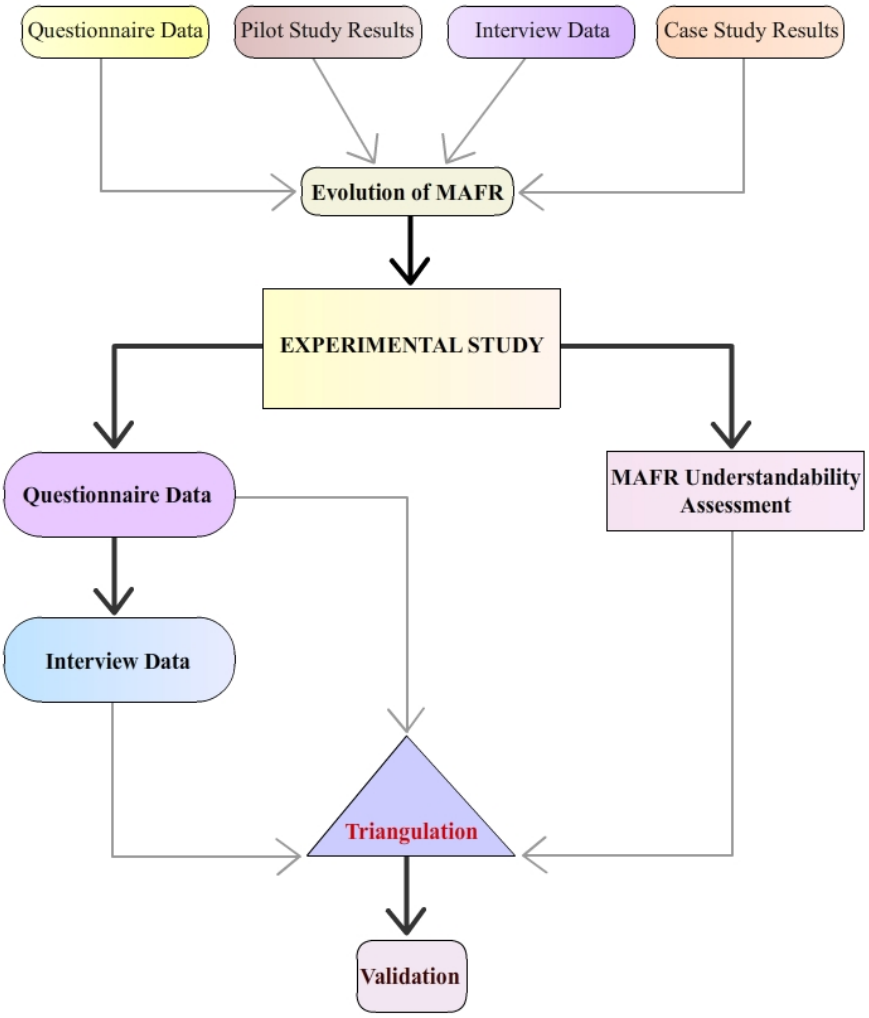


Figure 3.1 Research Procedure

3.5 Research Flow

In Figure 3.2 we indicated the research flow of this study. There are two main research parts in this study: Evolution of MAFR and Experimental Study. Therefore, research flow includes these two parts.

Evolution of MAFR part outputs the final MAFR and this MAFR has been the input to the experimental study part. Experimental study on the other hand has been designed to measure the understandability of MAFR.

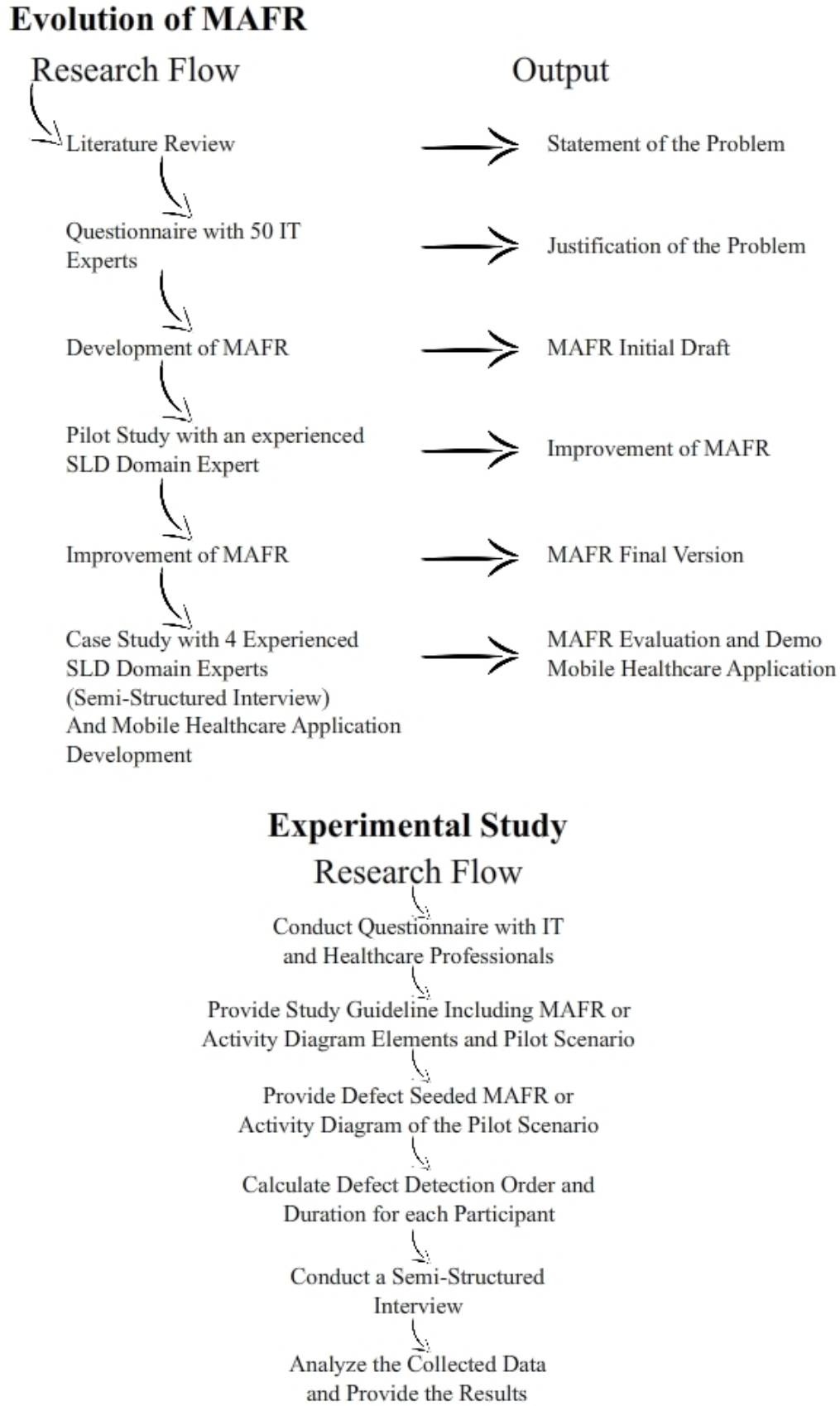


Figure 3.2 Research Flow

3.5.1 Evolution of MAFR

3.5.1.1 Literature Review

This study has started with the literature review on the following topics;

- Existing design guidelines
- Mobile application design guidelines
- UML for mobile environment
- Usage of UML in healthcare domain
- Mobile healthcare application development process

After the literature review on the topics above, the problem was stated and the research has started.

3.5.1.2 Questionnaire with IT Experts

Literature review was considered as a starter for the problem statement. However, to justify the problem and accordingly to increase the reliability, we decided to implement a questionnaire with IT experts. The questionnaire is given in Appendix A and it includes items about demographic information, Likert Scale, and open-ended questions.

This questionnaire is designed to gather the views of software developers to find out the communication problems between software developers and domain experts in software development process. Other than communication gap, attendees' opinions and experiences were tried to be collected with this questionnaire through the following topics;

- Experiences of IT experts regarding the software development process
- Problems that IT experts face during development process
- Differences between mobile and desktop application development process
- Models, tools and mediums used during software development process

This questionnaire was conducted with 50 experts from IT domain in a class setting and there were no time limitation for answering the questions.

3.5.1.3 Development of MAFR

After the problem statement and justification, a representation guideline was developed to mitigate the problem and we called this model as MAFR. It has been developed regarding the mobile agents' characteristics and it is based on mobile interface interaction actions.

To create our model we took the following steps;

- Look into existing models and studies
- Search for different devices like mobile phones, tablets and other handheld devices
- Seek for the characteristics of different mobile devices
- Seek for usability issues on mobile devices
- Search the limitation of mobile environment
- Define interaction methods, i.e. gestures. Figure 3.3 "Adapted from (The Design Inspiration, 2012)" shows some of gesture examples

- Define the representation elements considering the characteristics of mobile agents and gestures
- Visualize the representation elements
- Document the representation elements and propose the initial draft of MAFR

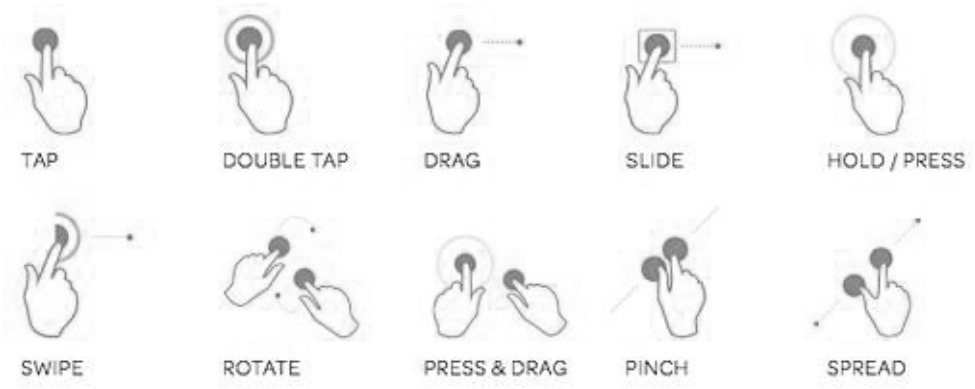


Figure 3.3 Gesture Examples

Proposed MAFR initial draft is given in Appendix B. For this initial version of MAFR, we have also assigned codes to the representation elements.

Representation elements are the shapes that are shown to the users. They can represent gestures, pages, buttons, pictures, videos, text fields etc. Each representation element has a name and a code. Codes are the identifiers for the elements. For example, if there are three "subpages (SP)" on the application, they are shown as "SP_1", "SP_2" and "SP_3". Similarly, if there are two "touch buttons (TB)" on the application, they are shown as "TB_1" and "TB_2".

For clarification, explanations should be as detailed as possible. For instance, if the application has a subpage (SP) with a "touch image (TI)", a "touch input text button (ITB)" and a "touch button (TB)" on it, they are pictured and coded as shown at Table 3.1.

Table 3.1 An Example of MAFR Notation

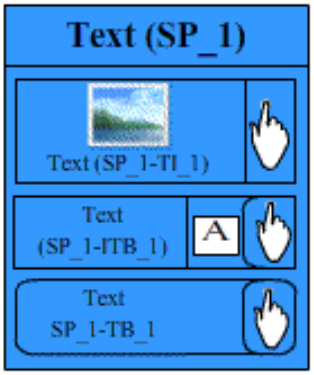
Figure	Explanation
	**SP_1** = Subpage One **SP_1-TI_1** = Touch Image One inside the Subpage One **SP_1-ITB_1** = Touch Input Text Button One inside the Subpage One **SP_1-TB_1** = Touch Button One inside the Subpage One

Figure 3.4 An Example Subpage

MAFR is composed of representation elements. Based on the user's action, they show the transactions between the pages within the mobile application. For example, considering the Figure 3.4, let's say that when the user touches on the "SP_1-TB_1", another subpage is opened with a "touch combobox button (CB)" and a "touch image (TI)" on it. Moreover, this TI can be zoomed in and out. The MAFR of this example is given below (Figure 3.5):

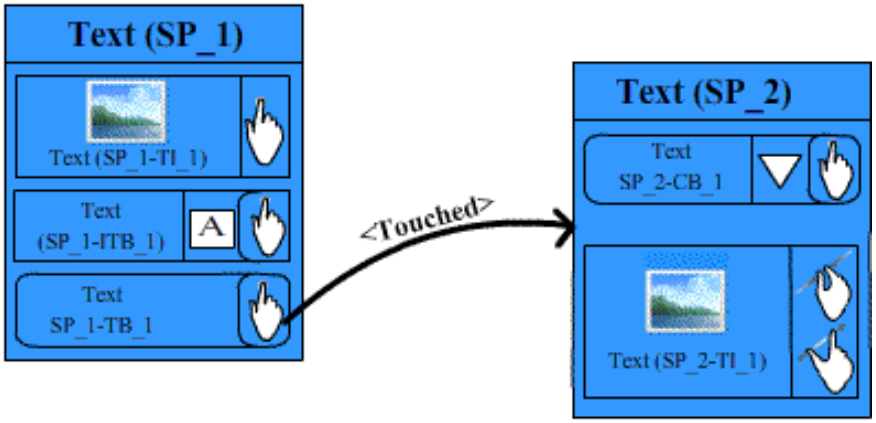


Figure 3.5 An Example of MAFR Initial Draft

The arrow shows transition based on users' action, which in this case "touch". This was the initial draft of MAFR and after we finalized the initial draft, we decided to test it with an SLD domain expert.

3.5.1.4 Pilot Study with Domain Experts and Improvement of MAFR

In this step of the study, we tested the initial version of MAFR with a SLD domain expert with 20 year experience in the field. This pilot study, the startup phase, was held one-to-one with the therapist. Her feedbacks were taken in person through a detailed examination. Critique from the expert has led us to improve the MAFR.

After the corrections and improvements, MAFR has been finalized. All the representation elements of MAFR are given in Appendix C.

3.5.1.5 Case Study with 4 Experienced SLD Domain Experts

After the final version of MAFR a case study with 4 experienced domain experts was held. For this case study participants were given a scenario and representation elements. They were asked to check the scenario and representation elements for 10 minutes. The scenario is about a "Kartopu (Snowball)" game which is used for SLD therapies. The scenario is given in Appendix D.

After the participants checked the elements and the scenario, they were asked to check the developed MAFR for "Kartopu (Snowball)" game. They were requested to think aloud during this process and their voices were recorded. Figure 3.6 shows the MAFR of Kartopu Game.

Figure 3.6 MAFR of “Kartopu (Snowball)” Mobile Game Application

After participants checked the model a semi-structured interview was conducted with each participant separately and sessions were recorded. Interview questions are given in Appendix E.

Following this case study, we have developed a demo mobile healthcare application. Figure 3.7 shows the main page of it and Figure 3.8 and Figure 3.9 show screens from “Kartopu (Snowball)” game.

Figure 3.7 Demo Mobile Healthcare App Home Page

Figure 3.8 Demo Mobile Healthcare App Kartopu (Snowball) Game View 1

Figure 3.9 Demo Mobile Healthcare App Kartopu (Snowball) Game View 2

3.5.2 Experimental Study with MAFR

After the evolution of MAFR, we wanted to verify our hypothesis which is “MAFR is much easier to understand than UML representations for both IT and healthcare professionals.” Moreover, we wanted to investigate our research questions. For this purpose we have used the Kartopu (snowball) game scenario and developed this scenario using MAFR and AD representations. Then, defects were seeded into those representations. Participants were divided into two groups randomly and there was not a criterion for the division. Each group is provided a study guideline including the scenario, representation elements of AD or MAFR and defect seeded AD of MAFR representations of the scenario. Table 3.2 shows the

provided materials to each participant group. Then, to determine whether MAFR increases understandability or not, participants were requested to find the defects on the provided model. Time spent to find a defect and defect detection orders were recorded.

Table 3.2 Provided Materials to Each Group

IT EXPERTS		**HEALTHCARE EXPERTS**	
Group 1	**Group 2**	**Group 1**	**Group 2**
Scenario of Kartopu (Snowball) Game	Scenario of Kartopu (Snowball) Game	Scenario of Kartopu (Snowball) Game	Scenario of Kartopu (Snowball) Game
Representation elements of AD	Representation elements of MAFR	Representation elements of AD	Representation elements of MAFR
Defect seeded AD of Kartopu Game	Defect seeded MAFR of Kartopu Game	Defect seeded AD of Kartopu Game	Defect seeded MAFR of Kartopu Game

With this experimental study the aim was to determine the difficulty level of the defects and participants' performance. As a result we wanted to test following points;

- **For IT Expert:** If the performance of participants at Group 2 is better than the performance of participants at Group 1 then MAFR is easier to understand than AD for IT Experts.
- **For Healthcare Expert:** If the performance of participants at Group 2 is better than the performance of participants at Group 1 then MAFR is easier to understand than AD for Healthcare Experts.

We used two formulas proposed by Cagiltay&Tokdemir et al. (2013) to find the participants' defect detection performance. One of the formulas is Defect Detection Difficulty Level and the other one is Defect Detection Performance.

For the Defect Detection Difficulty Level formula, Cagiltay&Tokdemir et al. (2013) considered two factors at defect detection: time spent for defect detection and defect detection order. In this context they have assumed following points:

- *The difficulty in detecting a defect is directly proportional to the time spent identifying the defect; if someone spends more time finding a defect, then it is harder to recognize than a defect that is detected in a shorter time.*
- *The difficulty in detecting a defect is directly proportional to the recognition order of the defect; the most easily detectable defects are recognized first.*
- *The difficulty in detecting a defect is inversely proportional to the number of people who recognized the defect; if a defect is detected by all the participants, then it is easier than a defect that is detected by fewer people.*

From those assumptions they proposed Defect Detection Difficulty Level formula as follow:

$$DF_j = \frac{D_j \bullet O_j}{S_j}$$

DF_j: Defect detection difficulty level of the jth defect

D_j: Average duration spent by all participants for finding defect j

O_j: Average score of all participants for detecting jth defect

S_j: Success rate of detecting defect j (Number of people who detected defect j/Total number of participants)

On the other hand, Defect Detection Performance formula was derived from defect detection difficulty level and it is represented as follow:

$$PP_i = \frac{\sum_{j=1}^{n} DF_j}{\sum_{k=1}^{s} DF_k}$$

PP_i: Defect Detection Performance of the ith participant

DF_j: Difficulty level of the jth defect calculated by formula 1

n: Total number of defects detected by participant i

s: Total number of defects seeded in the MAFR or AD.

Final formula is derived as follow:

$$PP_i = \frac{\sum_{j-1}^{n} \frac{D_j \bullet O_j}{S_j}}{\sum_{k-1}^{s} \frac{D_k \bullet O_k}{S_k}}$$

Which in fact **PP_i** is equal to “cumulative difficulty level of defects detected by Pi / to the cumulative difficulty level of all the defects seeded in MAFR or AD”

3.5.2.1 Questionnaire with IT and Healthcare Professionals

In this part of the research, we conducted a questionnaire with IT and healthcare professionals. This questionnaire was held just before starting the experimental study. IT and healthcare professionals were given different questionnaires. The questionnaire for IT

experts was the same the questionnaire given to IT experts at the “Evolution of MAFR” part and it is provided in Appendix A. The questionnaire for healthcare professionals on the other hand is provided in Appendix F.

The questionnaire for healthcare professionals includes demographic information on participants’ experience; items on technology perception as well as evaluation of current methods that they use in their therapies and what they want for their therapies.

In this study, to validate our findings and improve the reliability of this research we use triangulation method. Triangulation combines different research methods like qualitative, quantitative etc. to validate the findings of researches (Patton, 2002). Therefore, to increase the reliability of the formulas questionnaires and interviews were conducted with participants.

3.5.2.2 Study Guideline Including MAFR or AD Elements and Pilot Scenario

After the questionnaire, participants were given a pilot scenario (it is the same scenario used at the “Evolution of MAFR” part, see Appendix D) and the explanation about the representation elements of MAFR or AD.

3.5.2.3 Defect Seeded MAFR or AD of the Pilot Scenario

After the participants examined the study guideline they were given the defect seeded MAFR or AD of the pilot scenario. Figure 3.10 shows the defect seeded MAFR whereas Fig 3.11 shows the defect seeded AD. Half of the participants were given defect seeded AD and the other half were given defect seeded MAFR.

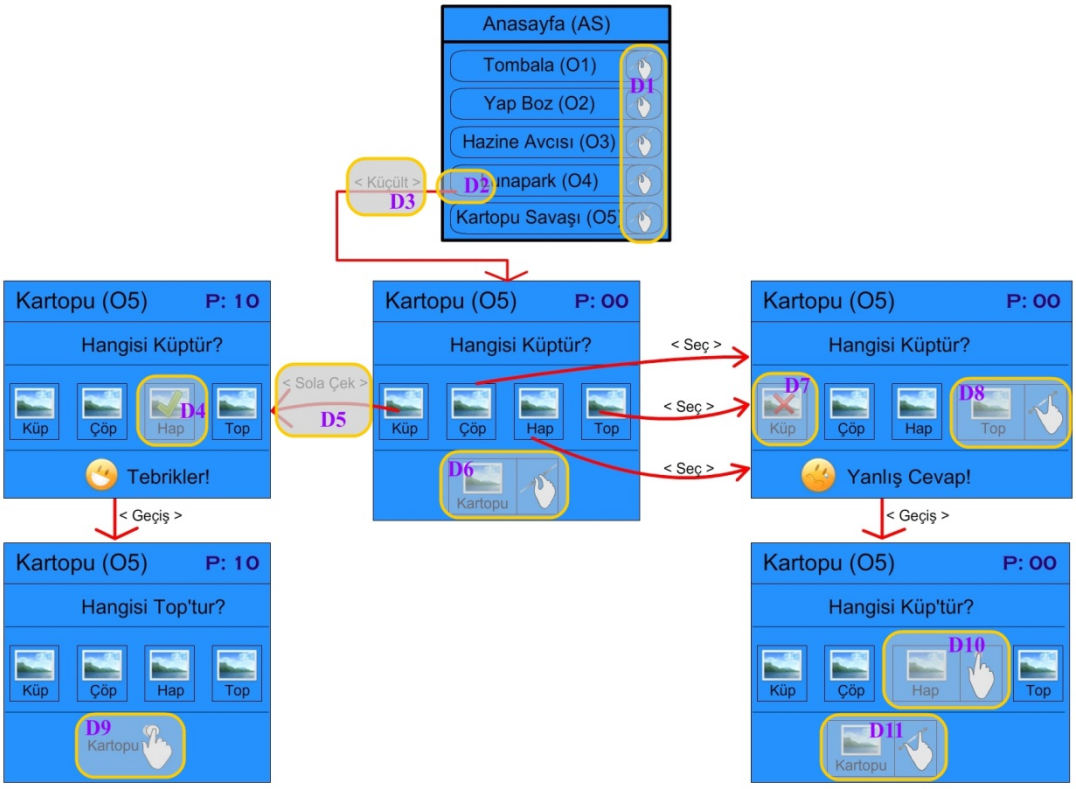


Figure 3.10 Defect Seeded MAFR

There are 11 defects on MAFR and they are stated below. These defects are related to the flow of the scenario and representation elements of MAFR.

Table 3.3 Defects Types on MAFR

Defect	Explanation
D1	Wrong type of button
D2	Wrong type of selection (wrong flow)
D3	Wrong type of explanation
D4	Wrong type of feedback
D5	Wrong type of explanation
D6	Wrong type of picture
D7	Wrong type of feedback
D8	Wrong type of picture
D9	Wrong type of picture
D10	Wrong type of picture
D11	Wrong type of picture

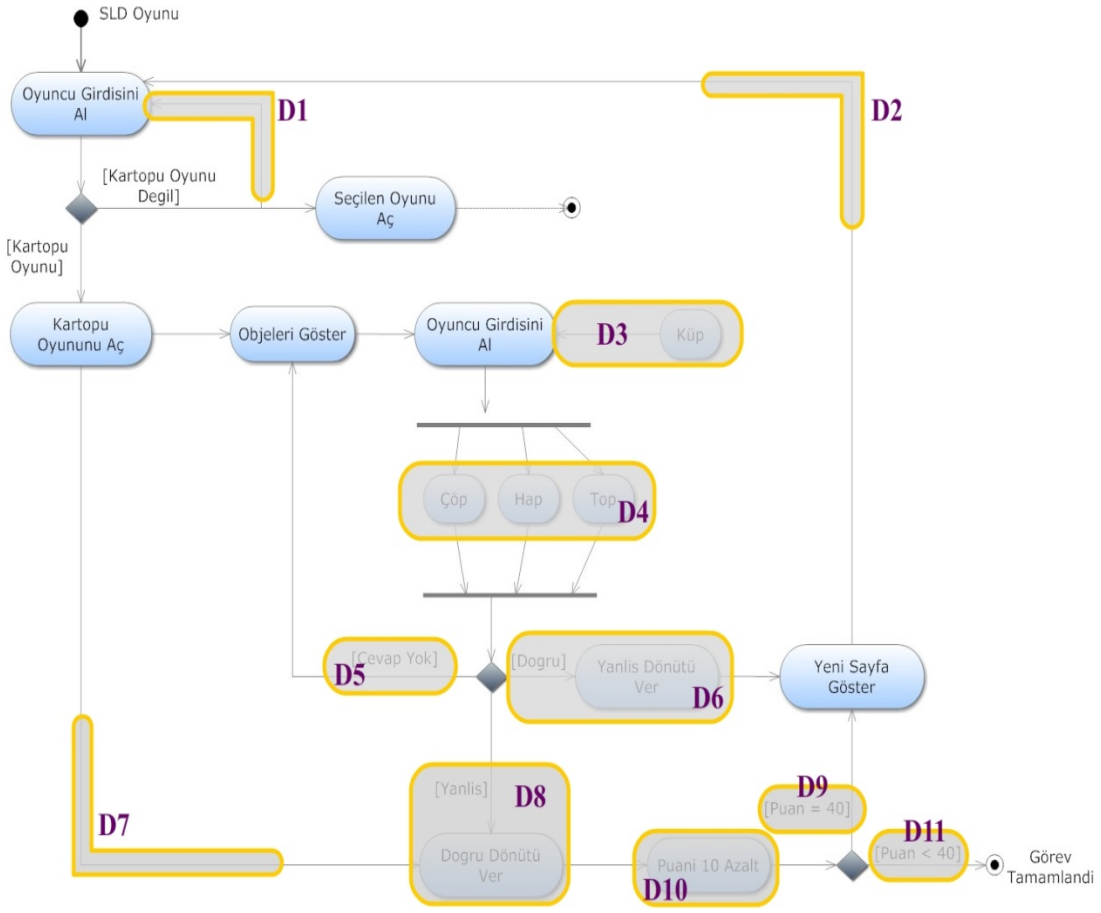


Figure 3.11 Defect Seeded AD

There are 11 defects on AD and they are stated below. These defects are related to the flow of the scenario and representation elements of AD.

Table 3.4 Defects Types on AD

Defect	Explanation
D1	Wrong flow
D2	Wrong flow
D3	Wrong place
D4	Wrong group
D5	Wrong explanation and wrong flow
D6	Wrong type of feedback
D7	Wrong flow
D8	Wrong type of feedback
D9	Wrong explanation
D10	Wrong type of feedback
D11	Wrong explanation

3.5.2.4 Recording Defect Detection Order and Duration for Each Participant

While the participants were trying to find the defects, we recorded the detection order and time spent to find the each defect. For this procedure we used an online web form (Figure 3.12). This form records the defect detection time and order of the participants. We requested from participant to use "Submit Defect" buttons when they find a defect and write the explanations in the provided text field. After they finished the study they submitted the form which sends an e-mail to us.

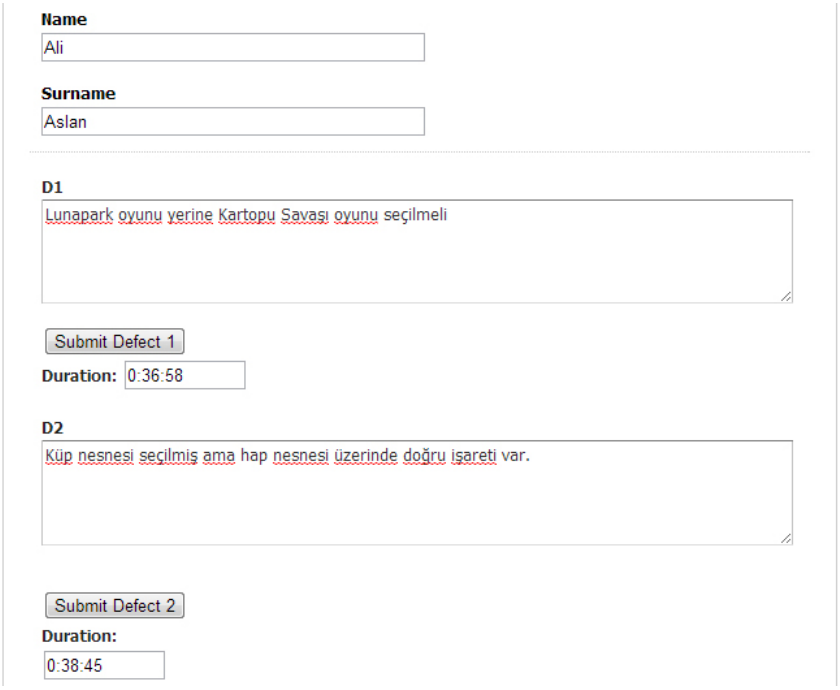


Figure 3.12 Online Web Form for Data Collection

3.5.2.5 Semi-Structured Interview

After the experimental study, a semi-structured interview was also conducted with each participant to get insights about the understandability of the MAFR representations and

defects. Interview questions are given in Appendix G. There are similar and different questions for IT and healthcare professionals regarding their expertise.

3.6 Data Analysis

For the evolution of MAFR and experimental study parts of this research mixed method analysis approach was implemented. Analyses have been made with the data collected through questionnaire, interview, case study and experimental study.

For the evolution of MAFR part, we have conducted interview, questionnaire and case study. Data from questionnaire was analyzed descriptively. Interview and case study data on the other hand were analyzed qualitatively and supported with pictures, schemas and guidelines. Moreover, results from case study have produced a pilot mobile healthcare application for patients with SLD.

As to experimental study part, questionnaire, interview and experimental study were conducted. Data from questionnaire represented descriptively. Moreover, data from interview has presented qualitatively and data from experimental study has stated both descriptively and qualitatively.

Likert Scale type items on the questionnaires were calculated based on the positive and negative scales. The scale was as follow: "(1) Strongly Disagree", "(2) Disagree", "(3) Neutral", "(4) Agree", "(5) Strongly Agree". Therefore, we consider 1 and 2 as negative answers, and 4 and 5 as positive answers. Moreover, the results of the questionnaires were compared with the results of the interview and experimental study (understandability assessment part) to measure the reliability of the participants' responses therefore the reliability of the questionnaires.

Defect difficulty level and participants performance formulas were applied to experimental study data and this data was analyzed with the independent sample T-Test analysis by using Ms Excel program. Interview data were analyzed qualitatively and this qualitative data has been compared with the one coming from questionnaires and experimental study.

CHAPTER 4

ANALYSIS AND RESULTS

In this chapter, results from both “Evolution of MAFR” and “Experimental Study” parts are given. Analyses and results are presented descriptively or qualitatively.

4.1 Evolution of MAFR

In this section, results from evolution of MAFR are given. Results from literature review, questionnaire with IT professionals, development of MAFR, pilot study with domain experts and improvement of MAFR, and case study with domain experts are stated descriptively or qualitatively.

4.1.1 Literature Review

As stated in the methodology chapter, our research flow started with the literature review on the following topics;

- Existing design guidelines
- Mobile application design guidelines
- UML for mobile environment
- Usage of UML in healthcare domain
- Mobile healthcare application development process

Table 4.1 shows the results from this review. Final result from the literature review showed that there is a need for innovative modeling tool for effective mobile healthcare application development process.

Table 4.1 Results from Literature

Topics	Results
Existing Design Guidelines	• There are different design guidelines used by IT sector. • UML has dominance in IT field.
Mobile application design guidelines	• Existing design guidelines tries to produce new method to transform the modeling according to mobile environment. • Mobile agents have different environment and this difference requires new modeling techniques.
UML for mobile environment	• There are studies on transforming UML to meet the requirements of mobile environment, but they are limited and not sufficient enough. • Complex for domain experts
Usage of UML in healthcare domain	• Healthcare is a complex field and have unique characteristics • UML is inadequate to meet these special needs of healthcare field
Mobile healthcare application development process	• For effective mobile healthcare applications, healthcare professional should be included in the development process • When healthcare professionals are stakeholders of the development process, communication gap occurs between IT and healthcare professionals
FINAL RESULT There is a need for innovative modeling tool for effective mobile healthcare application development process.	

4.1.2 Questionnaire with IT Professionals

Conducted questionnaire (Appendix A) with 50 people from IT domain produced different results. First of all Table 4.2 summarizes the participants of this questionnaire study.

Table 4.2 Participants of Questionnaire Study

Items	Number
Average Age	24
Average months of experience in programming	36
Average months of experience in the mobile programming	7
Male	39
Female	11
Total Participants	50

The participants of this study were students in their 3rd or 4th year of education from Atılım University, studying software engineering, information systems engineering or computer engineering. 78% of the participants were male, which is a normal gender distribution in these fields. In average, they had 36 months (3 years) of experience in programming including their education and on the job training programs. Additionally they had experience in mobile programming (including their education in this area) for an average of 7 months. Table 4.3 shows summary of participants' responses to questionnaire items.

Table 4.3 Participants' Responses to Questionnaire Items

Items **	**(1) %**	**(2) %**	**(3) %**	**(4) %**	**(5) %**
I need new tools and methods to communicate with customers easily during mobile software development process	2	16	33	41	8
A tool that facilitates the communication with customers reduces costs and shortens the software development process.	4	6	20	32	38
Customers should take place at every stage of mobile software development processes.	6	29	21	31	13
The great loss of time and cost in projects are caused by customers' needs which they cannot explain	4	8	18	33	37
I can express myself to customers easily during mobile software development process.	2	6	47	34	11
It is difficult to understand each other since we have different backgrounds with customers.	4	16	45	23	12

** "(1) Strongly Disagree", "(2) Disagree", "(3) Neutral", "(4) Agree", "(5) Strongly Agree"

Note: Parallel items are combined. That is why the table includes fewer items than questionnaire provided in Appendix A.

As seen from Table 4.3, the participants have reported that they experienced different kinds of problems during the development process. Results of the questionnaire showed that 50% of the participants needed new tools and models to describe the process to customers easily. Moreover, 70% of the attendees said that those kinds of tools and models could decrease both time spent on development process of the application and cost of the software. Furthermore, 45% of the attendees mentioned that customers should be in the software development process. Besides, 70% of the attendees stated that the reason why the software projects lasted more than the project time and exceeded the budget is that requirements are not clearly identified by the customers. 80% of the attendees mentioned that they had communication problems with customers because they either could not express themselves to customers or customers could not express what they want from them. 60% of the attendees thought that there was a communication gap between customers from different domains and people from IT domain.

Also in open-ended items of the questionnaire, most of the participants mentioned the importance of software requirements, because problems between customers and software developers were caused by unclear requirements and difficulties in communication. Moreover, as a model used in development process, most of the attendees used pictures, slides and storyboards. So, they needed a simple model that could be clearly understandable by both customers and people from IT domain.

From the questionnaire, it can be concluded that there is a communication gap between customers and people from IT domain during requirement collection phase of the software application which may result in exceeding of project cost and time. In order to fill this gap, it would be better to have new tools or models which will not only decrease the project time and cost but also increase the effectiveness of software application since the requirements are clearly identified.

Consequently, with these results we have referred to two of our research questions.

- Is there a communication gap between IT and healthcare professionals?

  Yes, there is a communication gap between IT and healthcare professionals.
- Do existing guidelines meet the need of the sector?

  No, existing guidelines do not meet the need; therefore, a more usable method is needed.

4.1.3 Development of MAFR

The result of the development process produced the initial draft of MAFR and given in Appendix B.

4.1.4 Pilot Study with Domain Experts and Improvement of MAFR

After the initial draft we have carried out a startup study with a SLD domain expert with 20 year experience in the field. According to the results we improved the MAFR and finalized it. According to the results following points were considered during the improvement of MAFR;

- Focus more on visual elements;
- Decrease the complexity;
- Consider all gestures.

First of all, representations were transformed from just a drawing to improved visual elements. Secondly, assigned codes were removed because they confused the domain expert and the model was more complicated. And finally we integrated more gestures because when domain expert saw a missing gesture she was confused.

Here are the explanations to the improvement of MAFR;

Example Scenario: Users touch on the cube image on the main screen and zoom it in and out.

MAFR: Figure 4.1 shows the MAFR of the given scenario before the improvement and Figure 4.2 shows the MAFR of the given scenario after the improvement.

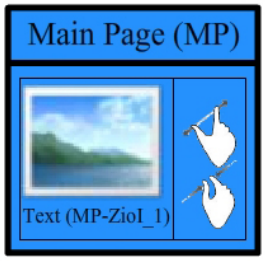


Figure 4.1 Initial Draft MAFR

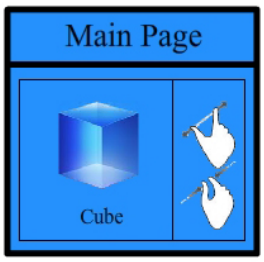


Figure 4.2 Improved MAFR

Moreover, after the feedbacks, we decided to combine MAFR with the more visual representations. In this context, if there is no interaction on an object we decided to put its image instead of putting its MAFR elements. For example in Figure 4.3 “Lunapark (Funfair)” game has an interface including tools in the funfair and one of them is a Gondola. Instead of putting an image representation of MAFR, we simply put the image of Gondola.

Figure 4.3 Example Notation

To give another example, while Figure 4.4 shows the MAFR without visual elements included, Figure 4.5 shows the MAFR with visual elements included.

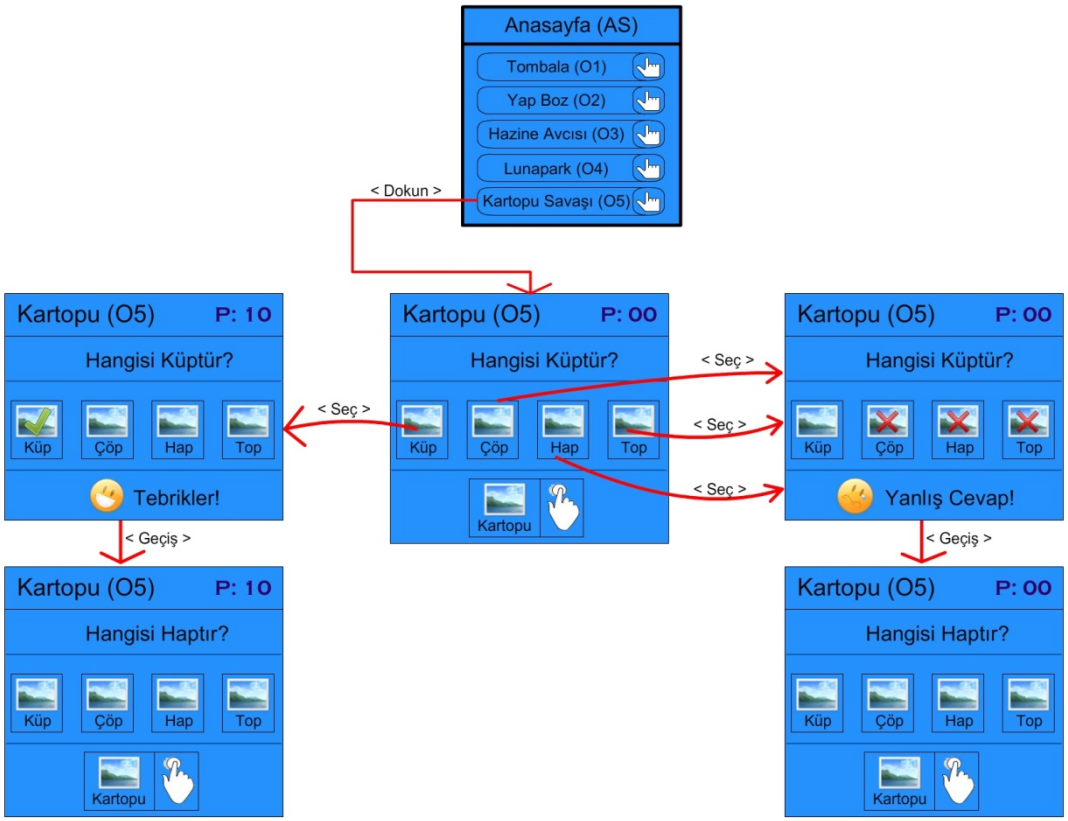


Figure 4.4 MAFR without Visual Elements Included

Figure 4.5 MAFR with Visual Elements Included

For the experimental study part of this research, we used MAFR without visual elements included, conversely, for the case study with 4 experienced SLD domain experts; we used MAFR with visual elements included. We also aimed to test the difference for both situations.

After the corrections and improvements, MAFR has been finalized. All the representation elements of MAFR are given in Appendix C.

4.1.5 Case Study with Domain Experts

Think aloud method used in case study and semi-structured interview have come up with different results. Table 4.4 shows the expertise of attendees.

Table 4.4 Expertise of the Interviewees

Participant	Expertise
P01	20 years of experience in language and speech disorder area, also a child development and education specialist.
P02	12 years of experience in language and speech disorder area, also a hearing-impairment teacher.
P03	9 years of experience in language and speech disorder area.
P04	3 years of experience in language and speech disorder area, also four years of experience in teaching of mentally disordered people.

Interviewee P02 said that "*using such kind of a model during development process is very effective*". Moreover, Interviewee P03 told that "*during software development process, face to face conversations are not always a good way and can be understood differently from person to person*".

All of the interviewees stated that they are fully satisfied with the proposed model and using this model makes the process efficient. During the usual development process, interviewee P01 stated that "*it is pointless to get domain experts' ideas after the development is over*". She mentioned "*the efficient way is correcting misunderstandings during the process*". For instance, in our case all the four therapists corrected different parts of our misunderstandings and neither therapists nor software experts have to perform development steps twice.

Finally, P01 and P04 stated that "*representation elements of this MAFR are so easy to understand that they don't even need to look at the explanations*". They said that "*most people can easily understand the elements*".

"*Have you ever been in a development process of a software or application?*" was one of the questions directed to interviewees. None of the therapists have been in a development process of a software or application. They just face with the application after it is developed. They stated that most of the applications they have faced with have serious problems which

have to be taken into consideration in terms of relevance to subject, relevance to exercises used in the field and need of patients in the target group.

"*What do you think about the MAFR?*", "*Did you understand the representation easily?*" were other questions. Therapists said that the representation elements can be understood easily.

"*What are the positive and negative parts of the MAFR?*" All of the interviewees stated that domain experts should definitely be included in the development process. However, most of the times they can't tell precisely what they want from the IT professionals and most of the times they don't understand what the IT professionals tell them. The positive part of this MAFR is that it is a common conversation platform for different professions. When it comes to the negative part of the MAFR, two of the interviewees stated that there is no need to represent all pages of the application with the MAFR. It should be as simple as it can be.

Consequently, results revealed that the proposed MAFR is considered to be beneficial during such kind of development process in terms of effectiveness and efficiency of the process.

4.2 Experimental Study

In this section results from experimental study part of this research are given. Results from this section are intended to answer the research questions.

4.2.1 Questionnaires with IT and Healthcare Professionals

IT and healthcare professionals were administered different questionnaires. Appendix A presents the one for IT professionals and Appendix F presents the one for healthcare professionals.

4.2.1.1 Results from Questionnaires with IT and Healthcare Professionals

40 IT professionals took the questionnaire. Table 4.5 shows the demographic profile of the participants and Figure 4.6 shows the age-gender distribution of participants.

72.5 % of the participants were men and 27.5 % were women. While their average software development experience was 35 months and their average mobile software development experience was 10 months. 57.5 % of the participants were between ages of 20 and 25. Moreover, 37.5 % of the participants were between the age of 26 and 30. Therefore, with the 95 %, it was a dynamic and young sample.

Table 4.5 Demographic Profile of IT Professionals

Items	**Average**	**Min-Max**	**SD**
Age	25	20 - 34	±2.9
Soft. Dev. Exp. (Month)	35	3 - 150	±31.3
Mob. Soft. Dev. Exp. (Month)	10	0 - 42	±11.1
Item		**n**	**%**
Gender:			
Male		29	72.5
Female		11	27.5

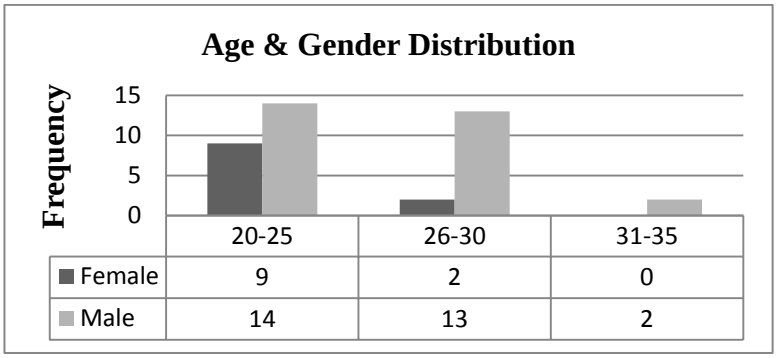


Figure 4.6 Age Gender Distribution of Participants

Furthermore, there were 16 Likert Scale questions in the questionnaire. However, they were grouped into 6 categories. To assure reliability, we asked same questions more than once by paraphrasing them. Table 4.6 shows the participants responses.

Table 4.6 Participants' Responses

Items **	**(1) %**	**(2) %**	**(3) %**	**(4) %**	**(5) %**
Mobile and desktop software development process are different from each other.	20	27.5	10	32.5	10
I can develop mobile software without using a software development model.	22.5	37.5	17.5	22.5	0
I can express myself to customers easily during mobile software development process.	2.5	22.5	32.5	35	7.5
Customers understand what I say easily during mobile software development process.	12.5	20	32.5	27.5	7.5
I understand what customers say easily during mobile software development process.	10	10	30	42.5	7.5
Customers should take place at every stage of mobile software development processes.	2.5	20	30	27.5	20
Existing software development process modelings meet my needs.	5	17.5	30	42.5	5
I need new tools and methods to communicate with customers easily during mobile software development process	0	20	20	45	15
I need a model for the effectiveness of mobile software development process.	0	10	20	52.5	17.5
I can reach to customers easily whenever I need during software development process.	5	27.5	37.5	22.5	7.5

Meeting with customers and gathering their ideas make me loose time.	22.5	30	12.5	20	15
It is difficult to understand each other since we have different backgrounds with customers.	2.5	32.5	25	22.5	17.5
Customers from different domains have different expectations and meeting those expectations is not always easy.	0	10	15	55	20
The great loss of time and cost in projects are caused by customers' needs which they cannot explain	0	12.5	10	30	47.5
I would like to use a tool which provides more easy communication with customers.	0	2.5	7.5	52.5	37.5
A tool that facilitates the communication with customers reduces costs and shortens the software development process.	0	0	10	47.5	42.5

** "(1) Strongly Disagree", "(2) Disagree", "(3) Neutral", "(4) Agree", "(5) Strongly Agree

According to results from participants' responses, IT professionals have difficulty in communication with customers and there is a need for innovative modeling or tools for the effective communication with them. Only 25 % of attendees thought that they can easily express themselves to customers and 50 % said that they can easily understand what customers say during mobile software development process.

Moreover, 70 % of participants stated that they need a model for the effectiveness of mobile software development process. 22.5 % of them said that existing software development process modeling tools meet their needs and 60 % needs new tools and methods to communicate with customers easily during mobile software development process.

Furthermore, results showed that there is a gap between customers and IT experts. 77.5 % of participants stated that great loss of time and cost in projects are caused by customers' needs which they cannot explain. In addition, 90 % of participants would like to use a tool which provides easier communication with customers and they think that such a tool reduces costs and shortens the software development process.

Results showed that there were many neutral answers to the items. This is related to the experiences of the participants. Since mobile technologies are emerging one, even most of the software developers have short experience in mobile environment. Half of the questions were related to mobile software development process. Therefore, it was acceptable to have such a result.

Consequently, IT experts face communication problems during software development process due to background differences. Existing models to mitigate this problem are not adequate and new methods and tools are needed.

As to SLD experts, 14 of them attended to the experimental study. All of them were female with the average age of 29 and owned at least one mobile device. Their average experience was 6 year with 2 year minimum and 13 year maximum. Table 4.7 shows the demographic profile of SLD experts.

Table 4.7 Demographic Profile of SLD Experts

Items	**Average**	**Min-Max**	**SD**
Age	29	25 - 35	±3
Domain Exp. (year)	6	2 - 13	±3.5
Item		**n**	**%**
Gender:			
Male		0	0
Female		14	100

Table 4.8 shows the results from participants' technology perception and experience. According to results, 93 % of participants stated that their literacy of computer is adequate and 64 % of them follow the technological developments. Moreover, 79 % of them said that use of computer is an obligation.

Furthermore, almost 80 % of the participants said that technology has completely changed the health service delivery.

From these numbers, it can be inferred that participants have a positive attitude to the technology and they actively make use of technology.

Table 4.8 Participants' Technology Perception and Experience

Items **	**(1) %**	**(2) %**	**(3) %**	**(4) %**	**(5) %**
I closely follow technological developments.	7	14.5	14.5	57	7
I think the level of my computer literacy is enough.	0	0	7	64	29
I think use of computers is a must.	7	0	14	29	50
I think mobile devices are used more than computers.	0	14.5	28.5	28.5	28.5
I follow all my work through my mobile device.	21.5	35.5	21.5	21.5	0
I think technology is overrated.	50	43	7	0	0
I think technology has completely changed health service presentation.	7	0	14.5	57	21.5

** "(1) Strongly Disagree", "(2) Disagree", "(3) Neutral", "(4) Agree", "(5) Strongly Agree

Table 4.9 shows the results about the perception of the present conditions regarding SLD experts' therapy sessions. 93 % of the SLD experts stated that therapy methods should be applied with the help of SLD expert. However, 50 % of them said that technology integrated therapy sessions are more effective than traditional ones. 93 % of them stated that multimedia tools are required for the therapy sessions.

Furthermore, only 43 % of the experts said that the methods they already use in their therapy sessions are adequate and efficient and 100 % of them stated that they prefer therapy sessions performed in an environment where oral, written and visual communication devices are involved.

Table 4.9 Perception of the Present Conditions Regarding Therapy Sessions

Items **	**(1) %**	**(2) %**	**(3) %**	**(4) %**	**(5) %**
I think multimedia tools like photograph, audio, video etc. are necessary for therapy sessions.	0	7	0	21.5	71.5
I think technology supported therapy sessions are more effective than conventional treatment sessions.	0	21.5	28.5	28.5	21.5
I think therapy methods should be applied only in company with specialists.	0	0	7	28.5	64.5
I think oral communication is solely enough for my therapy sessions.	43	50	7	0	0
I think the methods I already use in my therapy sessions are enough and fruitful.	0	21.5	35.5	35.5	7.5
I think exercises apart from therapy sessions that my patients do on their own or with the help of their relatives do more harm than good.	28.5	57	14.5	0	0
I think methods used in therapy sessions should change in parallel with technological developments.	0	7	21.5	50	21.5
I prefer therapy sessions are made in an environment where oral, written and visual communication devices are involved.	0	0	0	43	57

** “(1) Strongly Disagree”, “(2) Disagree”, “(3) Neutral”, “(4) Agree”, “(5) Strongly Agree

The result from Yes/No question of the questionnaire showed that 71 % of the participants doesn’t make use of mobile healthcare applications in their therapy sessions and they state the reason as existing mobile healthcare applications do not satisfy their needs and they are not effective for patients.

According to results from the questionnaire with therapist, we can state that SLD therapists are familiar with the technology, they have a positive attitude to technology and they think that technology is useful. However, most of them do not use mobile healthcare applications because they think that existing healthcare applications don't provide what they expect from them.

In summary, both questionnaires conducted with IT and healthcare professionals showed us the problems faced regarding the technology integration from both IT and healthcare domains.

4.2.2 Defect Seeded MAFR and AD

In this section difficulty levels and participants' performances regarding the defect detection are given.

4.2.2.1 Difficulty Levels of the Defects and Participants Performance

In this research there were 4 groups for the experimental study part and they are listed in Table 4.10. While each IT experts group has 20 participants, each healthcare experts group has 7 participants. Participants were randomly divided into the groups

Table 4.10 Study Groups

	IT EXPERTS		**HEALTHCARE EXPERTS**	
	Group 1	**Group 2**	**Group 1**	**Group 2**
Scenario	Scenario of Kartopu Game	Scenario of Kartopu Game	Scenario of Kartopu Game	Scenario of Kartopu Game
Representation Elements	Representation elements of AD	Representation elements of MAFR	Representation elements of AD	Representation elements of MAFR
Defects	Defect seeded AD of Kartopu Game	Defect seeded MAFR of Kartopu Game	Defect seeded AD of Kartopu Game	Defect seeded MAFR of Kartopu Game
n	**20**	**20**	**7**	**7**

Participants' performance for each group we performed Independent Sample T-Test Analysis. With this analysis we wanted to compare following points:

- **For IT Experts:** If the performance of participants at Group 2 is better than the performance of participants at Group 1 then MAFR is easier to understand than AD for IT Experts.
- **For Healthcare Experts:** If the performance of participants at Group 2 is better than the performance of participants at Group 1 then MAFR is easier to understand than AD for Healthcare Experts.

Table 4.11 shows the results from Independent Sample T-Test Analysis on participants' defect detection performance for healthcare experts groups. There is a significant difference between the performance of the groups taking AD and MAFR for healthcare experts.

Table 4.11 Participants' Defect Detection Performance for Healthcare Experts Groups

Item	AD (Group 1)	MAFR (Group 2)
Mean	0.248	0.516
Variance	0.010	0.017
Observations	7	7
Hypothesized Mean Difference	0	
Df	11	
t Stat	-4.325	
P(T<=t) two-tail	0.001	
t Critical two-tail	2.201	

Results showed that within the 0.05 confidence interval, and with t (11) = 2.201, the two-tailed P value equals p = 0.001. By conventional criteria, this difference is considered to be extremely statistically significant. This significance states that the performance of participants taking AD (Group 1) (M= 0.24, SD=0.098) much less on mean compared to the performance of participants taking MAFR (Group 2) (M=0.51, SD=0.1313). Therefore, we can conclude that MAFR is much easier to understand than AD for healthcare experts. Figure 4.7 shows the defect detection performance of healthcare experts taking AD and MAFR.

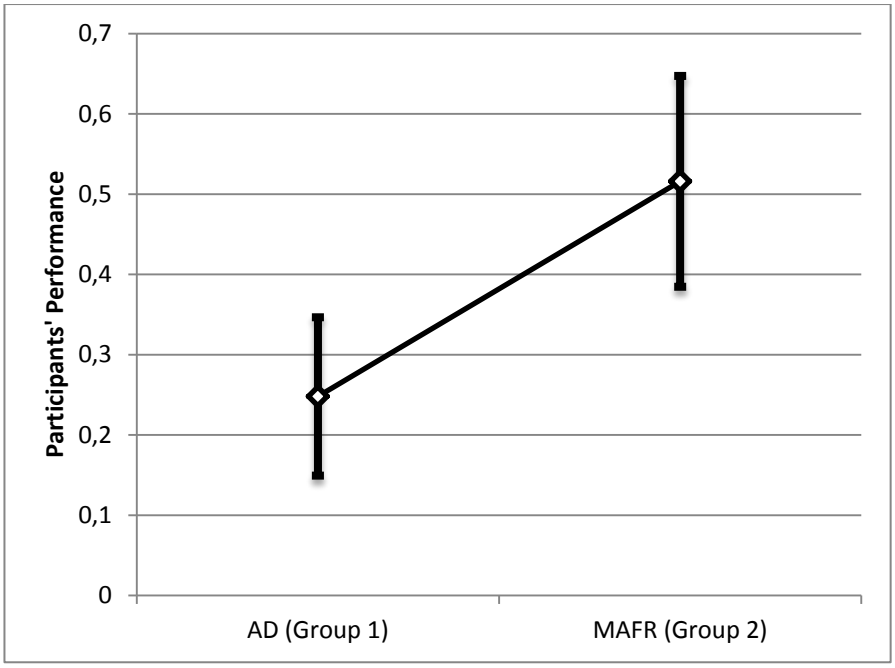


Figure 4.7 Defect Detection Performances of Healthcare Experts Taking AD and MAFR

Another Independent Sample T-Test Analysis was conducted on participants' defect detection performance of IT experts groups. Table 4.12 shows the results from this analysis. There is a significant difference between the performance of the groups taking AD and MAFR for IT experts.

Table 4.12 Participants' Defect Detection Performance for IT Experts Groups

Item	AD (Group 1)	MAFR (Group 2)
Mean	0.457	0.575
Variance	0.016	0.037
Observations	20	20
Hypothesized Mean Difference	0	
Df	33	
t Stat	-2.289	
P(T<=t) two-tail	0.029	
t Critical two-tail	2.035	

Results showed that within the 0.05 confidence interval, and with t (33) = 2.035, the two-tailed P value equals p = 0.029. By conventional criteria, this difference is considered to be statistically significant. This significance states that the performance of participants taking AD (Group 1) (M= 0.45, SD=0.128) less on mean compared to the performance of participants taking MAFR (Group 2) (M=0.57, SD=0.759). Therefore, we can conclude that MAFR is easier to understand than AD for IT experts. Figure 4.8 shows the defect detection performance of IT experts taking AD and MAFR.

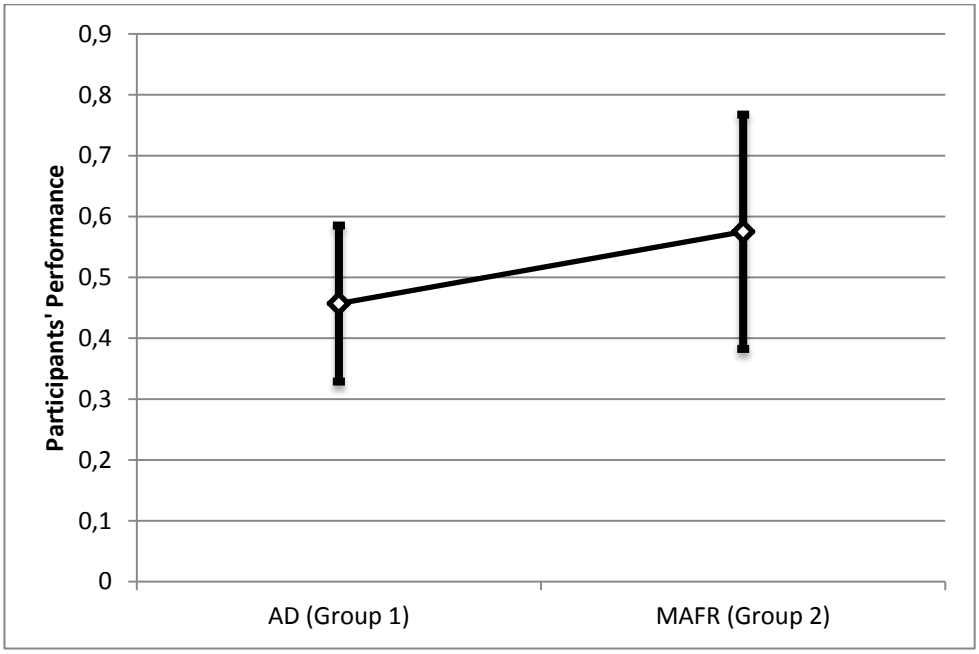


Figure 4.8 Defect Detection Performance of IT Experts Taking AD and MAFR

We also looked for the performances of the IT experts on MAFR and AD considering their experiences. Table 4.13 shows IT experts' defect detection performances on MAFR considering their experiences.

Table 4.13 IT Experts' Defect Detection Performances on MAFR Considering Their Experiences

Item	Student	Professional
Mean	0.620	0.531
Variance	0.031	0.058
Observations	10	10
Hypothesized Mean Difference	0	
df	16	
t Stat	0.942	
P(T<=t) two-tail	0.360	
t Critical two-tail	2.120	

Results showed that within the 0.05 confidence interval, and with t (16) = 2.120, the two-tailed P value equals p = 0.360. By conventional criteria, this difference is considered to be not statistically significant. This result states that the performance of IT experts who are still students on MAFR (M= 0.62, SD=0.176) is not statistically different compared to the performance of IT experts who work professionally in an IT company on MAFR (M=0.53, SD=0.241). Therefore, we can conclude that IT experts show similar behaviors on MAFR regardless of their professional experiences. Figure 4.9 shows the defect detection performances of professionals and inexperienced IT experts on MAFR.

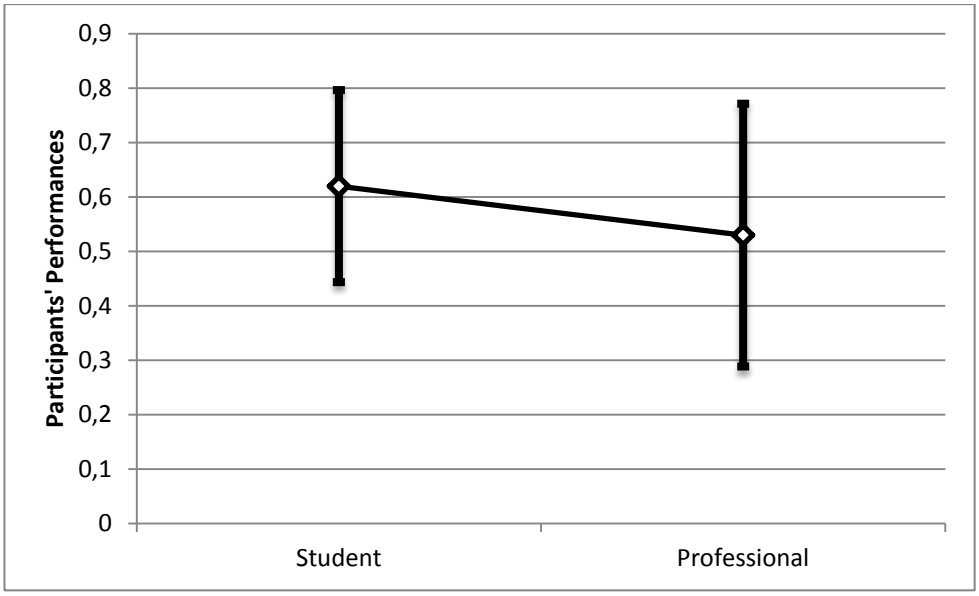


Figure 4.9 Performances of Professionals and Inexperienced IT Experts on MAFR

On the other hand, Table 4.14 shows IT experts' defect detection performances on AD considering their experiences.

Table 4.14 IT Experts' Defect Detection Performances on AD Considering Their Experiences

Item	Student	Professional
Mean	0.462	0.454
Variance	0.025	0.011
Observations	10	10
Hypothesized Mean Difference	0	
df	16	
t Stat	0.136	
P(T<=t) two-tail	0.894	
t Critical two-tail	2.120	

Results showed that within the 0.05 confidence interval, and with t (16) = 2.120, the two-tailed P value equals p = 0.894. By conventional criteria, this difference is considered to be not statistically significant. This result states that the performance of IT experts who are still students on AD (M= 0.462, SD=0.15) is not statistically different compared to the performance of IT experts who work professionally in an IT company on AD (M=0.454, SD=0.107). Therefore, we can conclude that IT experts show similar behaviors on AD regardless of their professional experiences. Figure 4.10 shows the defect detection performances of professionals and inexperienced IT experts on AD.

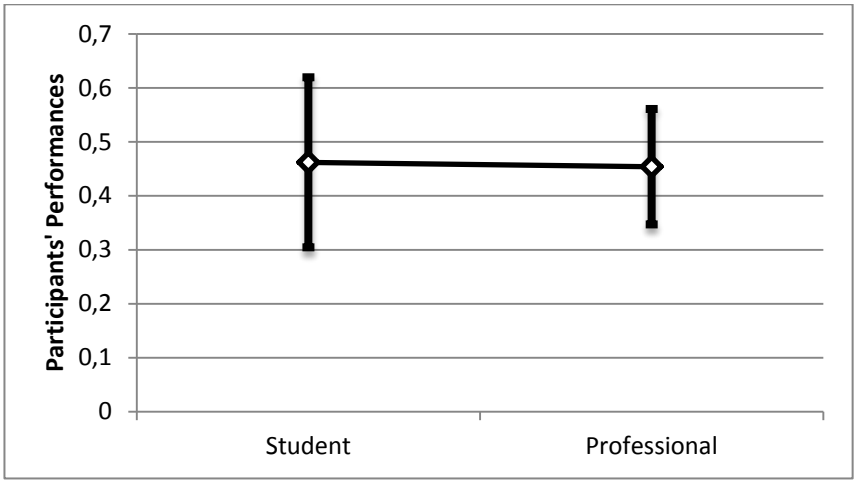


Figure 4.10 Performances of Professionals and Inexperienced IT Experts on AD

4.2.3 Semi-Structured Interview

After the experimental study a semi-structured interview was conducted with healthcare experts who took AD and MAFR and with IT experts who took MAFR. Since AD is a well known UML representation by IT experts, we didn't conduct the interview with the ones who took AD.

Question 1. Have you ever participated in any software development process? (For healthcare experts)

Have you ever worked with domain experts in software development process? (For IT experts)

Table 4.15 Participants' Answer to the Interview Question 1

Participants	Yes	No
IT Experts	19	1
Healthcare Experts	4	10
n	23	11

Table 4.15 illustrates the participants' answer to the interview question 1. As it is evident from the Table 4.15, although only 4 healthcare experts have participated in a software development process, 19 IT experts have worked with domain experts before.

This is an expected result for both IT and healthcare professionals. However, most of the IT experts who answer this question "Yes" stated that if it is not an internal project (if the company develops the project for itself) of the company it is natural for us to work with customers, but not always these customers are domain experts of a specific subject. They can be the sponsor of the project.

Question 2. Do you experience communication problems with people from IT sector? If you do, do you think such a model will contribute to solving this communication problem? (For healthcare experts)

Do you experience communication problems with people from IT sector? If you do, do you think such a model will contribute to solving this communication problem? (For IT experts)

Table 4.16 Answers of Healthcare Experts to the Interview Question 2

Participants	Model Taken	Answers
P1	MAFR	I have difficulty in transferring my domain specific knowledge. People from IT think that technology will handle every problem we have but in reality I think technology has just a supportive role in this context. I think this model may contribute to the problem we face with IT experts.
P2	AD	Since people from IT have different expertise, it is natural that we have communication problem between us. I am not sure if this model would help to solve this problem.
P3	MAFR	Most of the time I don't understand what people from IT say and they repeat what they want to say again and again. This takes too much time for us to get along. This model can help us and reduce the time we spent.
P4	MAFR	Our field is a special one requiring specific knowledge. Therefore IT experts should understand this domain knowledge and implement the applications accordingly. However, we take education on this field for 4 years and they expect us to transfer this knowledge in a couple of meeting. In such a short time, normally, they don't understand us and vice versa. This model can help to fill this gap but I am not sure if it covers everything we need.

According to Table 4.16 healthcare professionals who take place in a software development process think that they have communication problems with IT experts and proposed MAFR can help to solve this problem. However, they are not %100 confident about that.

As to IT professionals who previously worked with customers their answers regarding their previous experiences are stated below.

Table 4.17 Answers of IT Experts to the Interview Question 2

Participants	**Model Taken**	**Answers**
6 of the Participants	MAFR	If it is a specific field I face with communication problem, but if it is a general one like preparing a website of a company we understand each other with customers. This model can help to fill this gap. Its notations are easy to understand.
9 of the Participants	MAFR	I definitely have difficulty in transferring what I want to say to the customers. This model may help but there are other models like state diagrams, sequence diagrams, so there is no need to use a new one.
4 of the Participants	MAFR	I don't have any problem in communication with customers.

It is apparent from Table 4.17 that only 4 of the participants think that they understand what customers say and they don't have any problem in communication with customers. However, almost 80 % of the participants who took MAFR, stated that they have difficulty in communication problems. 60 % of those who face with communication problem stated that proposed MAFR may be a solution but there is no need for such a model because they already use different models. 40 % of those who face with communication problem stated that proposed MAFR notations are easy to understand therefore it can be an alternative model to fill this gap.

Question 3. Did you have difficulty in finding the defects on MAFR (or AD) given to you?

Question 4. Do you think you understood enough the MAFR (or AD)?

Question 5. Can you easily draw the MAFR (or AD) of another given scenario?

Question 9. What is your comment when you consider the MAFR (or AD) shown to you, in terms of complexity?

With the questions 3, 4, 5 and 9, it was aimed to measure the complexity of the given model. Therefore, results are combined.

Table 4.18 Answers of Healthcare Experts to the Interview Questions 3, 4, 5, 9

Participants	Model Taken	Answers
3 of the Participants	MAFR	It was hard for me to find the defects. Actually the study guideline was easy but I have difficulty in finding the defects. I believe I can draw the MAFR of another scenario but I am not definite.
4 of the Participants	MAFR	It was easy for me to find the errors. It is an understandable notation. If you give me more time to study I can easily draw the MAFR of another scenario. It is not so difficult to understand.
5 of the Participants	AD	It was hard for me to find errors so I couldn't find the defects. I think I don't understand it and I cannot draw the AD of another scenario. It is pretty complex.
2 of the Participants	AD	I don't think that I understand this notation at all. It is hard for me to understand.

According to the answers given the question 3, 4, 5, and 9 healthcare professionals understand the MAFR better than AD. These results verify that our independent sample T-Test analysis has produced correct results.

Table 4.19 Answers of IT Experts to the Interview Question 3, 4, 5, 9

Participants	Model Taken	Answers
13 of the Participants	MAFR	Yes it was hard for me to find the defects. I did my best but I don't think I understand the model.
7 of the Participants	MAFR	No it was easy for me to find the errors. It is an understandable notation but I prefer to use UML notation.

According to the answers given the question 3, 4, 5 and 9, 65 % of IT experts who took the MAFR had difficulty in finding the defect. However, our independent sample T-Test Analysis has produced opposite results. Even IT experts stated that MAFR is difficult for them; they got higher scores compared to the ones who took AD. Actually this was an expected outcome, because IT experts had already known about AD. Therefore, it is normal for them to think that MAFR is complex and they may prefer UML.

Question 6. Do you think you can transfer a scenario that you used in your therapy sessions to an IT team only by using MAFR (or AD)? (For healthcare experts)

Do you think you can transfer a scenario that you used in your projects to a domain expert only by using MAFR? (For IT experts)

Table 4.20 Answers of IT and Healthcare Experts to the Interview Question 6

Participants	Model Taken	Answers
7 Healthcare Experts	MAFR	I don't think I can tell about a scenario by just using this model, but I can use this model as a supportive tool.
7 Healthcare Experts	AD	It is not such kind of a model that I can transfer my knowledge to IT experts.
20 IT Experts	MAFR	This model will make the things easier but I don't think I can transfer the information to domain experts by just using it.

It can be seen from the data in Table 4.20 that MAFR can be a good supportive material during software development process however it would be unrealistic to think that the information can easily be transferred by using it alone.

Question 7. Do you think MAFR (or AD) provides time effectiveness in development process or is verbal communication more time effective?

Table 4.21 Answers of IT and Healthcare Experts to the Interview Question 7

Participants	Model Taken	Answers
7 Healthcare Experts	MAFR	Verbal communication is important, however it should be supported with the materials like pictures, schemas etc. MAFR could be a good supportive material and provide time effectiveness.
7 Healthcare Experts	AD	Verbal contact is important however it should be supported with the materials like pictures, schemas etc. AD could be a supportive material but only if it would be simpler, it could provide time effectiveness.
20 IT Experts	MAFR	It definitely provides time effectiveness but it should be supported with verbal communication. It is an integrated process.

As it is stated at Table 4.21 MAFR can be a good supportive tool during development process and it can provide time effectiveness.

Question 10. What are your suggestions for the MAFR (or AD) shown to you?

Table 4.22 Answers of IT and Healthcare Experts to the Interview Question 10

Participants	Model Taken	Answers
7 Healthcare Experts	MAFR	It would be better if it is more visual.
7 Healthcare Experts	AD	It should be simpler. It is hard for us to understand.
20 IT Experts	MAFR	It definitely provides time effectiveness but it should be supported with verbal communication. It is an integrated process.

CHAPTER 5

DISCUSSION AND CONCLUSION

In this chapter, the results derived in the preceding chapters are discussed. Moreover, suggestions for future work are stated.

5.1 Discussion

As stated in the "Introduction" chapter, with this study it is hypothesized that proposed MAFR is much more understandable than UML notations for both IT and healthcare professional. In congruence with this hypothesis, the following research questions were posed:

RQ1: Is proposed MAFR easier than UML representations for IT and healthcare professionals?

RQ2: Does proposed MAFR increase the understandability and reduce the communication gap during mobile healthcare application development process?

RQ3: Is there a communication gap between IT and healthcare professionals during mobile healthcare application development process?

RQ4: Do existing modeling tools (i.e. UML, ERD etc.) meet the need of the mobile environment and healthcare sector?

RQ5: Could healthcare professionals transfer the domain knowledge to the IT experts by just using MAFR?

RQ6: Would MAFR save time for the mobile healthcare application development process?

Our research flow has started with the literature review on existing software design modeling tools for mobile environments especially for the healthcare field. Results show us that there is a need for innovative modeling tool for effective mobile healthcare application development process. With this literature review we have addressed RQ3 and RQ4.

> "*There is a communication gap between IT and healthcare professionals during mobile healthcare application development process*."

> "*Existing modeling tools do not meet the need of mobile environment and healthcare sector*."

There could be two ways to meet these needs stated above: either transforming existing design guidelines according to the requirements of technological improvements, mobile environment and healthcare domain or developing a new design guideline. Transforming existing design tools according to the requirements of technological improvements, mobile environment and healthcare domain may result in complexity. Even existing guidelines, especially UML representations embraced by IT field; are too complex for domain experts to understand. If it is continued to add new properties, attributes or notations to these representations according to the constantly changing technology requirements, they will be more complicated not only for domain experts but also for IT professionals. Therefore, developing a new design tool specific to mobile environment would be a better alternative solution.

The problems defined as a result of literature review part have been justified through a questionnaire conducted with 50 IT experts. Regarding the results RQ3 and RQ4 have been addressed once again.

After the problem statement and verification, a new representation guideline (MAFR) was proposed which would contribute to the solution. A first draft of MAFR is prepared, tested with an experienced domain expert as a startup and improved. After that case study was implemented and MAFR was finalized. From the results and these diligent efforts on proposed MAFR it is inferred that during the development of such a model, domain experts' viewpoints are crucially important. The proposed model should be so simple that when the domain experts see it, he/she can directly understand it.

Developed MAFR was an input to the experimental study. As a first step in the experimental study part, questionnaires with IT and healthcare professionals were conducted with the aim of collecting data on the perception of mobile application development process, current situation and problems that the participants face during application development process, current situation for the therapy sessions regarding the involvement of technology, participants' technology experience and technology perception. Results of the questionnaires conducted with IT experts corroborate the findings of the questionnaire that we have implemented during the evolution of MAFR part. With these results we have addressed two research questions RQ3 and RQ4: There is a communication gap between IT and healthcare professionals, and existing guidelines doesn't meet the need, therefore, a more usable method or solution is needed. Moreover, questionnaire with healthcare experts showed that SLD experts support the technology however they have difficulty in finding effective mobile healthcare applications. We think that this is caused by the lack of domain knowledge of IT experts. Therefore, domain experts should be included in development process. Moreover, within the experimental part RQ1, RQ2, RQ5 and RQ6 were tried to be answered.

After the questionnaires, a study guideline was provided to the participants including representation elements of MAFR or AD, and a scenario (Kartopu game scenario) used in SLD therapies. Following the study guideline a defect seeded MAFR or AD of the Kartopu game scenario was provided to the participants and they were requested to find the defects. With this process, the aim was to define the defect detection order and time spent to find each defect, which would lead us to the participants' performances. Results from this process directed us to answer RQ1 and RQ2. We also verified that our hypothesis is true.

"*MAFR is much more understandable than UML notations for both IT and healthcare professional.*"

"*MAFR increases the understandability and reduce the communication gap during mobile healthcare development process*"

As a final step, we have conducted a semi-structured interview with the participants. Results have addressed to RQ5 and RQ6.

"MAFR could be an effective tool for transferring the knowledge; however, by using it alone, all the knowledge cannot be transferred. Therefore, it can be considered as a supportive tool."

"By increasing the understandability in mobile healthcare application development process MAFR is expected to provide time advantage for both IT and healthcare professionals."

Furthermore, this study proved that healthcare experts have a different way of understanding than IT experts. With this study, it is resulted that if healthcare experts are provided with a tool through which they can transfer their domain knowledge to IT experts, they will be more into the topic and as a result more effective mobile healthcare applications can be developed.

On the other hand, we think that the communication gap will always be an issue for IT and healthcare professionals. The way they think depends on the education they got and this is the main point. Unless IT experts are educated as medical stuff or vice versa, the communication gap will always exist. However, that is not a good method and a difficult solution. Using a method like MAFR would be much better to reduce this communication gap.

We proposed a method for the problems stated above and findings, while preliminary, suggest that MAFR deserves further attention. Moreover, these results provide supplementary support for the hypothesis that MAFR is much more understandable than the existing UML guidelines. Consequently, using MAFR as a tool during mobile healthcare application development process could reduce communication gap between IT and healthcare professionals.

Finally, in this study we focused mostly on the understandability of MAFR in terms of healthcare domain as well as user interface. Therefore, it is as simple as possible. However, IT field has advanced internal processes related to system design, architecture design and database design. Currently, they use different UML diagrams for these advance processes. Whether MAFR could also be used in those processes is out of the scope of this study. This topic can be considered for future studies and studies can be made on the topic that if MAFR can be mapped to the internal development processes of IT field or not. In this research we wanted to keep the proposed model as easy as it can be so that domain experts can

understand. However the context can be extended to different domains as well as different specific scenarios.

5.2 Future Work

In this research a method to improve the communication of IT and healthcare professionals during mobile healthcare application development process has been proposed. Our results showed that it is an understandable tool; however, more research needs to be undertaken to generalize the results. Further research should be carried out to investigate the benefits of MAFR, because we tested MAFR on only one domain which is SLD. Future studies on different fields are therefore recommended.

Moreover, we developed a pilot mobile healthcare application for SLD patients but this development can be extended to speech recognition for future studies. With this way, a more advanced scenario could be tested by using MAFR and this ensures to prove the effectiveness of it.

Furthermore, in future investigations it might be possible to use different scenarios, especially specific scenarios of specific fields. Also, 14 SLD experts participated in this study, and the sample size could be increased for more reliable results.

Finally, as stated before, studies on whether MAFR can meet the requirements of the internal processes of IT field could be implemented. For example, the topics “Could MAFR be used for database design or architecture design of mobile applications?” or “Could it be mapped with the system design procedures?” can be studied.

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APPENDIX A

QUESTIONNAIRE ON SOFTWARE DEVELOPMENT PROCESSES

This questionnaire is designed to gather the views of software developers to find out the the communication problems between software developers and domain experts in software development process. Also, this questionnaire results will provide the elimination of these communication problems by developing an innovative software development model. The data collected in this questionnaire will be examined to determine communication problems between software developers and domain experts in software development process. For this reason, it is very important to answers to questionnaire questions for this process, and we thank you for your help.

1. Participant Information (This information in this part will not be share with 3rd parties.)

Age	
Gender	
Working Unit/Position	
Software Development Experience(Year-Month)	
Mobile Software Development Experience (Year-Month)	

2. Efficiency of Mobile Software Development Process

Choose the most suitable option according to your experience. (1 – Strongly Disagree,

2 – Disagree, 3 - Neutral, 4 – Agree, 5 – Strongly Agree)

Efficiency of Mobile Software Development Process	**1**	**2**	**3**	**4**	**5**
Mobile and desktop software development processes are different.					
Without any software development process, I can develop effective mobile software.					
I can express myself to customers easily in mobile software development process.					
Customers can easily understand what I say in mobile software development process.					
I can easily understand what customers say in mobile software development process.					
Customers should take place at every stage of mobile software development processes.					
Existing methodologies of software development process meet my needs.					
I need new tools and methods to communicate with customer in mobile software development process.					
I need a model for the effectiveness of mobile software development process.					
I can easily reach the customers when I need them in software development process.					
It is a waste of time by organizing meetings with customers and getting their ideas.					
It is difficult to understand each other since we have different backgrounds with customers.					
There are different expectations of different customers. It is not easy to reach all of them and communication with all of them.					
The great loss of time and cost in projects are caused by customers' needs that they cannot explain.					
It will be good to have a tool which provides easier communication with customers.					
A tool facilitating the communication with customers will reduce costs and shorten the software development process time.					

2. Mobile and Desktop Software Development Process

Which software development model do you use while developing mobile software?

What are the problems that encountered most in collecting application requirements in mobile software development process?

What are the most encountered problems in mobile software development process?

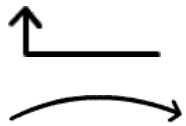
What are the tools that you use to communicate with customer in mobile software development process? (Figure, Diagram, Picture, etc.)

What are the most important factors that you lead to be successful (software is completed on time and developed as customer needs) in software development process?

What are the most important factors that you lead to be successful (software is not completed on time and does not satisfy the customer needs) in software development process?

APPENDIX B

MAFR INITIAL DRAFT

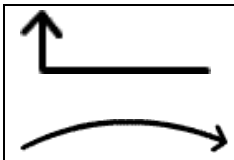
Notation	Name	Explanation
	Touch (T)	Touch on the related element.
	Touch and Hold (T&H)	Touch on related element and hold your finger for a while
	Slide right or Slide left (→S←)	Touch on the element and with the finger touched on it; slide it to the right or to the left.
	Zoom in (Z+)	Touch on the related element with two fingers and with the fingers touched on it, zoom in the related element.
	Zoom out (Z-)	Touch on the related element with two fingers and with the fingers touched on it, zoom out the related element.
	Drag object (→D←)	Touch on the related element and with the finger touched on it, drag the related element.
	Action line	Action line direct the user to the related page based on the users actions. This line shows that what the application will display next.
< text >	Explanation for the action line	Used for explaining action lines. For example, if related item is a touchable item, explanation will be <touched>.

	Main page (MP)	Shows the main page of the application. When the application is run, this page will be showed to the user.
	Subpage (SP)	Based on users' selection from the main page, this page will be showed as a subpage.
	Touch button (TB)	Shows that user can touch on the button.
	Touch combobox button (CB)	Shows that user can touch on the combobox therefore, the list in the combobox will be showed to the user.
	Touch radio button (RB)	Shows that user can touch on the items listed, i.e. user will mark the item by touching on it.
	Touch checkbox button (CBB)	Shows that user can touch on the items listed, i.e. user will mark the item by touching on it.
	Touch input text button (ITB)	Shows that user can touch on the textbox and make an input.
	Touch Image (TI)	Shows that user can touch on the image.

APPENDIX C

MAFR FINAL VERSION

Notation	Name	Explanation
	Touch	Touch on the related element.
	Touch and Hold	Touch on related element and hold your finger for a while
	Slide right or Slide left	Touch on the element and with the finger touched on it; slide it to the right or to the left.
	Zoom in	Touch on the related element with two fingers and with the fingers touched on it, zoom in the related element.
	Zoom out	Touch on the related element with two fingers and with the fingers touched on it, zoom out the related element.
	Drag object	Touch on the related element and with the finger touched on it, drag the related element.
	Rotate Object	Touch on the related element with two fingers and rotate.
	Double Touch on Object	Touch on the related element double time in succession.

	Action lines	Action lines direct users to the related page based on the users actions. This line shows that what the application will display next.
< text >	Explanation for the action line	Used for explaining the action line. For example, if the related item is a touch item, the explanation will be <touched>.
	Main page	Shows the main page of the application. When the application is run, this page will be showed to the user.
	Subpage	Based on users' selection from the main page, this page will be showed as a subpage.
	Popup page	Represents the pop up page
	Touch button	Shows that user can touch on button.
	Drag button	Shows that user can drag the button
	Touch combobox button	Shows that user can touch on the combobox therefore, the list in the combobox will be showed to the user.
	Touch radio button	Shows that user can touch on the items listed, i.e. user will mark the item by touching on it.
	Touch checkbox button	Shows that user can touch on the items listed, i.e. user will mark the item by touching on it.

	Touch input text button	Shows that user can touch on the textbox and make an input.
	Image	Represents the image without interaction
	Touch Image	Shows that user can touch on the image.
	Drag Image	Shows that user can drag the image.
	Zoom out Image	Shows that user can zoom out the image.
	Zoom in Image	Shows that user can zoom in the image.
	Video	Represents the Video
	Others (O)	Special buttons for specific applications. It can be unique to that application and shown as what it is look like. This symbol is put for exceptional cases.

APPENDIX D

KARTOPU (SNOWBALL) GAME SCENARIO

Speech and Language Disorders Therapy System

Speech and Language Disorders Therapy System will be an application consisting of 5 different games and each game will contribute to individuals' development of writing, perception etc. When the application is first opened, there will be 5 touch buttons on the Main Page in sequence, belonging to below games.

- Tombola (Tombala) Game
- Jigsaw Puzzle (Yap Boz) Game
- Treasure Hunter (Hazine Avcısı) Game
- Funfair (Lunapark) Game
- Snowball (Kartopu Savaşı) Game

For this scenario, please think that user picks the snowball game.

Kartopu (Snowball) Game

In snowball game, 4 images on screen will be shown to the individual, and one of the images name will be written. The individual will try to hit the indicated image with the 'Draggable Snowball Image' to win points.

The first images to come in the game are in turn Cube, Ball, Stick and Pill. First, user will be asked 'Which is Cube?' and they will be asked to hit the Cube with draggable snowball. If they can hit the Cube, they will get Congratulations ☺ and 10 points feedback. If they hit a wrong object instead of the Cube, they will get 'Wrong Answer' ☹ feedback. After this transition, the individual will be asked to answer the question 'Which is the Ball?' to the 4 images that will come as the Stick instead of the Cube.

The game will end after the individual answers below questions in turn:

- Which is the Cube?
- Which is the Ball?
- Which is the Stick?
- Which is the Pill?

APPENDIX E

CASE STUDY INTERVIEW QUESTIONS

Question 1) How long is your expertise in the field?

Question 2) We want to develop a system/software which you can use at your therapy sessions. In this context, do you think that these kinds of systems/software can be suitable to your therapies?

Question 3) Have you ever been to such kind of software development process? If so, could you please mention about the process?

Question 4) What were your expectations before the process and what were the problems you had faced during the process?

Question 5) In terms of clarity and the understandability, what are the positive parts of model that we have just showed to you?

Question 6) In terms of clarity and the understandability, what are the positive and negative parts of model that we have just showed to you?

Question 7) What are your suggestions about MAFR?

APPENDIX F

QUESTIONNAIRE WITH HEALTHCARE PROFESSIONALS

Speech and Language Disorders Domain Expert Questionnaire

This questionnaire has been prepared to evaluate the Speech and Language Disorders Domain Experts' perception of the use of technology in their own field, to determine how mobile technologies that will be used in treatment sessions are welcomed by domain experts and to find out the experiences of domain experts in use of mobile health applications. The data collected by this questionnaire will be examined to evaluate present conditions. Therefore, we hope that you will minutely fill in the questionnaire and we thank you in advance for your help.

1. Participant Information (The information in this part will not be shared with 3rd parties.)

Sex	
Age	
Field of Specialty	
Duration of Specialty	
Mobile Device Possession	☐ I have a mobile phone ☐ I have a smart phone ☐ I have a tablet PC ☐ I have a handheld PC

2. Perception of Technology and Experience

Please choose best option considering your experience.

(**1** – Strongly disagree, **2** – Disagree, **3** Neutral, **4** – Agree, **5** – Strongly agree)

Perception of technology and Experience	**1**	**2**	**3**	**4**	**5**
I closely follow technological developments.					
I think the level of my computer literacy is enough.					
I think use of computers is a must.					
I think mobile devices are used more than computers.					
I follow all my work through my mobile device.					
I think technology is overrated.					
I think technology has completely changed health service presentation.					

3. Perception of the present conditions

Please choose best option considering your experience.

(**1** – Strongly disagree, **2** – Disagree, **3** Neutral, **4** – Agree, **5** – Strongly agree)

Perception of the present conditions	**1**	**2**	**3**	**4**	**5**
I think multimedia tools like photograph, audio, video etc. are necessary for therapy sessions.					
I think technology supported therapy sessions are more effective than conventional treatment sessions.					
I think therapy methods should be applied only in company with specialists.					
I think oral communication is solely enough for my therapy sessions.					
I think the methods I already use in my therapy sessions are enough and fruitful.					
I think exercises apart from therapy sessions that my patients do on their own or with the help of their relatives do more harm than good.					

I think methods used in therapy sessions should change in parallel with technological developments.					
I prefer therapy sessions are made in an environment where oral, written and visual communication devices are involved.					

3.1. I make use of mobile health applications in my treatment sessions.

☐	**Yes**		
☐	**No…**	☐	There is no mobile healthcare application that I can use.
		☐	Present mobile healthcare applications do not satisfy my needs.
		☐	Present mobile healthcare applications are not effective for patients.
		☐	Present mobile healthcare applications are impractical.

Please specify other comments and suggestions.

APPENDIX G

EXPERIMENTAL STUDY INTERVIEW QUESTIONS

Question 1) Have you ever participated in any software development process? (For healthcare experts)

Have you ever worked with domain experts in software development process? (For IT experts)

Question 2) Do you experience communication problems with people from IT sector? If you do, do you think such a model will contribute to solving this communication problem? (For healthcare experts)

Do you experience communication problems with people from IT sector? If you do, do you think such a model will contribute to solving this communication problem? (For IT experts)

Question 3) Did you have difficulty in finding the defects on MAFR (or AD) given to you?

Question 4) Do you think you understood enough the MAFR (or AD)?

Question 5) Can you easily draw the MAFR (or AD) of another given scenario?

Question 6) Do you think you can transfer a scenario that you used in your therapy sessions to an IT team only by using MAFR (or AD)? (For healthcare experts)

Do you think you can transfer a scenario that you used in your projects to a domain expert only by using MAFR? (For IT experts)

Question 7) Do you think MAFR (or AD) provides time effectiveness in development process or is verbal communication much more time effective?

Question 8) What kind of method have you followed through finding the defects?

Question 9) What is your comment when you consider the MAFR (or AD) shown to you, in terms of complexity?

Question 10) What are your suggestions for the MAFR (or AD) shown to you?

APPENDIX H

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: ERTURAN, Yusuf Nasuh

Nationality: Turkish (TC)

Date and Place of Birth: 26.09.1987 / Mersin

Phone: +90 507 227 06 99

EDUCATION

Degree	Institution	Year of Graduation
M.Sc.	Medical Informatics	2013
B.S.	METU Computer Education and Instructional Technology	2010
High School Graduate	Mersin Yahya Gunsur Anatolian Comp. Vocational High School	2005

PROFESSIONAL EXPERIENCE

Year	Place	Enrollment
2012 – present	Nart Informatics (TechN'arts)	Business Analyst
2010 – 2012	METU Instructional Technology Support Office	Research Assistant
2009 – 2010	BITES Defence & Aerospace Technologies	Instructional Technologist

PUBLICATIONS

1. Erturan, Y. N., Bilgen, S., Tokdemir, G., Cagiltay, N., Yildiz, E., Ozcebe, E. (2013). A Mobile Application Flow Representation for Mutual Understanding of IT and Healthcare Professionals. *Lecture Notes in Computes Science, 8004*, 310-319.

2. Erturan, N., Gürel, N., Cevik, R., Çağıltay, K. (2012). *Eğitimde Webinar (Sanal Sınıf) Kullanımı: Ticari (Adobe Connect) ve Açık Kaynak (OpenMeetings) Webinar Uygulamalarının Karşılaştırılması*. Akademik Bilişim, 2012, Uşak, Türkiye, 1-3 Şubat 2012.

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü	
Sosyal Bilimler Enstitüsü	
Uygulamalı Matematik Enstitüsü	
Enformatik Enstitüsü	X
Deniz Bilimleri Enstitüsü	

YAZARIN

Soyadı : ERTURAN
Adı : Yusuf Nasuh
Bölümü : Tıp Bilişimi

TEZİN ADI (İngilizce) : A METHOD TO IMPROVE THE COMMUNICATION BETWEEN INFORMATION TECHNOLOGY AND HEALTHCARE PROFESSIONALS DURING MOBILE HEALTHCARE APPLICATION DEVELOPMENT PROCESS

TEZİN TÜRÜ : Yüksek Lisans [X] Doktora [ ]

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın.	
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın.	
3. Tezim bir (1) yıl süreyle erişime kapalı olsun.	X

Yazarın imzası ..... Tarih .....