Journal of Engineering and Applied Sciences 13 (2): 291-297, 2018
ISSN: 1816-949X

Usability Evaluation of DEAF Mobile Application Interface: A Systematic Review

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Abstract: Mobile applications for deaf is getting popularity but lacking in evaluating the usability of these applications. Existing models to evaluate mobile applications is very general to be applied in identifying usability problem for the special need people. This study investigates few important dimensions to be applied in developing a usability evaluation model for mobile applications for deaf specifically. Systematic Literature Review (SLR) is used in achieving this objective with identification of dimensions that support usability model development. A total of 515 papers were downloaded and has been narrowed down into 44 articles that finally selected for the study. The results show that the most usability dimensions appear in the articles are effectiveness, efficiency, learnability, accessibility and satisfaction which contribute towards measuring the usefulness of mobile application meant to the deaf community.

Key words: Mobile application, SLR, usability model, deaf, community, contribute

INTRODUCTION

Mobile phones that has been previously used mainly for incoming and outgoing of calls now has become standalone product that is very useful for daily activity. Now a days, mobile phones are owned by almost everyone. High demand for mobile smart phones have opened the eyes of many researchers to study the areas in the mobile application (Zhang and Adipat, 2005). Besides receiving incoming and outgoing calls, messages as well as video messages, mobile phone has reached an era of usage in different environment and industry. Many areas have gained benefits from the utilization of mobile daily such as disaster, logistics, managements and more. Use of mobile phones does not bound only for normal people but it is accessible to disabled people equally comfortably. Compatibility of mobile phones for easy communication is being studied continuously to enhance the usability for all groups of people (Alsumait and Osaimi, 2009; Potter *et al*., 2011; Hussain and Kutar, 2012; Masitry *et al*., 2013). Thus, mobile application has the need to be useful and even more usable. As for the case of hearing impaired people there are mobile application developed to serve the community need for communication and learning. However, many hearing impaired always look forward application that commonly used by everyone to make their communication easier. Meanwhile, mobile application for hearing impaired play significant role in the disabled person's daily life. In a study on German hearing impaired usage of technology by Power and Power (2004) found that 96% had access to mobile phone and using at least basic text messaging application every day. Though many may seem counterintuitive that hearing impaired have no need for voice telephone capabilities but mobile platform has open various communication channels that were not available previously. For instance, hearing impaired is also considered to be drawn towards the usage of mobile phone and many applications being developed such as sign language learning, short messaging service specifically for hearing impaired and many more. Mobile application developed especially for hearing impaired is really a must have for all the hearing impaired to enable them to mingle around with the society regardless of the disability.

An effective interface of an application will enable the user to achieve a high degree of satisfaction in using the application, especially when the application caught their attention by addressing the requirements and needs adequately. Beside the basic mobile phone application, many researchers come forward to develop applications which focused on video sign language transmission application (Cavender *et al*., 2006; Halawani, 2008; Lin *et al*., 2010; Weaver *et al*., 2010; Boulares and Jemni, 2012). The ease of use would affect user satisfaction towards the application and their performance level will be affected as well (Tory and Moller, 2005). While ISO 9241-11 defines usability as a product which can be specified by users in achieving goals and effectiveness as well as efficiency in the context of use. It is also known as easiness for users to learn operating and interpreting the inputs of the system. Acceptability of users towards an application depends largely on the satisfaction of the user. Usability dimension is a pivotal part of the usability

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evaluation (Coursaris and Kim, 2011). The goal of a good usability is about selecting minimal dimensions which could respond, to a maximum level of usability details (Coursaris and Kim, 2011). According to ISO dimensions that were recommended for usability studies include the three main component which is the effectiveness, efficiency and satisfaction. While Nielsen previously has noted that a system's usability depends on the five major dimensions which is efficient, error, satisfaction, learnability and memorability. However, it may not be appropriate in all the situation and for all the applications. This is because, in many cases developers tend to develop in the manner that basic guidelines could satisfy user in general and few important issues about how the system work in the hand of the user and in determining whether the system really useable been omitted.

Measuring usability is a significant aspect that will ensure the effectiveness of an application towards users. There is a need for usability evaluation methods that would be able to guarantee the satisfaction of user towards mobile application and enable in capturing usability issues arises during development process. This issue has been the focus of many studies, though it is not specifically for hearing impaired. The usability issues and criteria will be able to determine on the design of an application interface with functionality and satisfaction for the user (Coursaris and Kim, 2011; Baharuddin *et al*., 2013). This study conducts review of related studies with current measurement factor and methods for usability evaluation of mobile application interface for deaf people through Systematic Literature Review (SLR).

MOBILE APPLICATION FOR DEAF

Previously to enable hearing impaired people to communicate with normal people, Teletypewriter (TTY) was used traditionally. However, TTY needs both person to have the device and type the messages back and forth. If one of them does not have the TTY, they need third party operator that can translate the messages into an electronic transmission form and forward it back. As the mobile phone popularity is increasing, hearing impaired no longer used TTY for communication (Lang, 2000). Mobile application nowadays available for common usage. Many applications such as messaging, video conferencing, social media application are developed with general usage in mind despite there might be some difficulties that could be faced by disabled people. Survey by National Association of the deaf found that 75% of the hearing impaired are using instant messaging and 97% are using emails daily. It shows that though the challenges and limitation of these applications and the technology appears, hearing impaired is the community that adopts the technology, especially, telecommunication technology faster (Power and Power, 2004).

This shows there are many enhancements and enrichment that could be taken into consideration to support the hearing impaired when developing general applications. Applications specifically for hearing impaired mostly concerned with communication and learning which includes a sign language interpreter, video messaging service, text messaging service which converts text into speech and vice versa. There are also games and religious learning purpose application that addresses particularly for hearing impaired for the mobile application. Various studies agreed that many advantages can be gained by the specified applications but user's satisfaction for the interface usability might be an effect of the less popularity. Studies also stated that usability enacted did not fully sufficient for user need because the usability depicted for general and disregards special needs people (Yeratziotis and Greunen, 2013).

As such, technology and mobile application are used by technical savvy people more rather than slower learners as hearing impaired people. When the technology is unreliable it will be abandoned (Abascal *et al*., 2016). Thus, hearing impaired people rely more on close relations than technology (Yeratziotis and Greunen, 2013) and usage of the hearing impaired application lesser. Such things need to be addressed to bridge gaps to justify that advantages of mobile application does not only for normal users but as well as for hearing impaired users. There is also a drawback for the application, whereas the user has to update the versions frequently that might be baffling for some hearing impaired users. Despite all that, the mobile application is viewed as one of the interesting and most used by all the people across the globe and this figure of users will increase in the close future (Coursaris and Kim, 2011).

SYSTEMATIC LITERATURE REVIEW (SLR) METHOD

Steps involved in SLR can be divided into three which is planning about the review to be conducted, then conduct the review process through searching for information and selecting primary studies to be included and excluded into the studies and finally reviewing the results obtained through reporting the results. These three steps can be explained thoroughly with Fig. 1.

Planning the review: Research question has been generated to ensure planning process conducted smoothly. Through this research question development, more focus can be given for searching process and

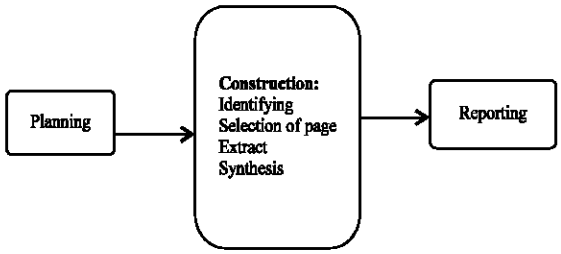

Fig. 1: SLR method

filtering the sources and articles acquired for the study. Following research questions have been investigated through the SLR process to achieve aim of this study which is. What are the generic and specific dimensions to measure usability for deaf mobile applications?

Conducting the review: The searching of the needed articles in this study ensures that SLR should detail the high quality of the searched paper and articles. The main aim of this phase is to investigate on the dimensions that can be used as a measurement for usability evaluation of the interface for deaf mobile applications. A combination of both primary and specific dimensions is the expected result to be obtained. For that, this study applies the following search string:

- C1 (\usability") AND (\evaluation" OR \dimensions" OR \metric")
- C2 (\hearing impaired" OR \deaf")
- C3 (\Mobile" OR \Phone" OR \Phones") AND (\Applications")

Eventually, the complete string used in the searching process was:

- C1 AND C2 AND C3

Papers that have been selected have been downloaded and sorted according to journal and conference proceedings from year 2006 onwards. Top HCI journals such as Software Quality Journal, International Journal of HCI, Journal of Usability studies with IEEE and ACM databases was used in identifying the journals. Total of seven top HCI journals was identified and few other HCI journals are also considered due to the lacking of information in terms of deaf mobile applications and its usability. Table 1 shows top most selected publications that was considered for the SLR.

Table 2 shows total of 515 journals and conference proceedings papers that been downloaded. Following that total of 44 papers was selected for depth review. The main focus given on the selected paper and articles is based on usability dimension and measurement and relevancy to the deaf people applications. Thus, the total downloaded paper was revised and analysis and chosen most relevant paper according to the study which is total of 44 articles as in Table 3.

Reporting the review: The main objective of the study is identifying appropriate usability dimensions for deaf mobile application interface evaluation. Therefore, five dimensions have been identified and explained as.

Effectiveness: Refers the completeness that enables user to achieve specified goals (Coursaris and Kim, 2011; Hornbaek, 2005; Hussain and Kutar, 2009; Kim *et al*., 2014). To measure the effectiveness of an interface for hearing impaired application, simplicity of an application interface plays a vital role. The interface must be clear and not confusing for the user and enable user to return to the main page successfully. As for hearing impaired, they requested for more easy to see and learn interface, since, the complex interface might confusing for them and enabling the struggle in completing a task (Lang, 2000; Ameiri *et al*., 2012). Graphic, readability of the output and simple layout of the interface added to the presentation value for the hearing impaired application (Yeratziotis and Greunen, 2013). Time taken in completing a task and total errors that are less contributing to better effectiveness of the system (Lin *et al*., 2010; Seffah *et al*., 2006; Bhuiyan *et al*., 2014). This contributes in achieving the effectiveness of an application.

Efficiency: Efficiency is about the level of a product or application that enable tasks to be done quickly and effectively (Coursaris and Kim, 2011; Hornbaek, 2005). Loading time is referring to the time taken to load the application and allow user to start and perform their task (Hornbaek, 2005). For example, consuming more time for the application to respond to user action lead to the mind-set that the application is difficult to be operated. This is also because, taking hearing impaired, particularly in mind, whereas the community would feel the application is difficult for them and feel the strain and develop less interest in using the application (Yeratziotis and Greunen, 2013; Baharuddin *et al*., 2013). While compatibility will ensure the extent of the interface that is platform friendly and limitation in input output process (Baharuddin *et al*., 2013; Harrison *et al*., 2013). Input output process with total number of clicks in achieving the goal of a task ensuring the compatibility of any application (Hornbaek, 2005). Integrating both loading measurement and compatibility will ensure the efficiency of an application for the hearing impaired.

Table 1: Journal and proceedings

Journals/Conferences	Publisher	Descriptions
Software Quality Journal	Springer science	Collection of software quality articles
International Journal of Human Computer Interaction (IJHCI)	Taylor and Francis	Basically on human relation with the system elements both quantitative and qualitative studies
Journal of Usability Studies	JUS	Basically review on usability attempts in making technology much easier and relevant. Mostly on quantitative studies
International Journal of Computer Science Education (IJCSE)	Association of Computer Machinery (ACM)	Focuses on human relation with the system
International Journal of Mobile Human Computer Interaction (IJMHCI)	IGI Global	Collection of articles on design, evaluation, mobile technology and wearable technologies
International Conference on Human Computer Interaction with Mobile Device and Services (CHCI)	ACM	Challenges and effective interaction solution
International Journal of Computer Studies (IJCSI)	Science Direct	Interdisciplinary journal on computing, artificial intelligence, psychology, communication and more which is relevant to the design, analysis of innovative interactive systems
Journal of Deaf Studies	Gallaudet Publisher	Issues pertaining deaf
Other H_I related (Int Journal of Behavioural Sciences, Int Journal of Tech, Int Journal of Science and Tech)	Science Direct, Taylor and Francis	Issues on hearing-impaired and technology related to HI discussed
International Conferences/Proceedings	ACM, IEEEE	International conference and proceedings was presented and well discussed

Table 2: Journals and proceedings papers downloaded

Journals	‘06	‘0.7	‘0.8	‘0.9	‘10	‘11	‘12	‘13	‘14	‘15
Software Quality Journals	1									
IJHCI	2		1							
Journals of Usability Studies	1					1				
IJCSE							3	1		
IJMCHI								1		
CHCI	1	1						1		
IJCSI							1			
Otherhi Journals	2	2	2	1	1		1	1	1	2
ACM	2	1	1		1	1	1	2		
IEEE					5	1			1	
Total	9	4	4	1	7	3	6	6	2	2

Table 3: Selected journal or proceedings paper for review

Journals	‘06	‘0.7	‘0.8	‘0.9	‘10	‘11	‘12	‘13	‘14	‘15
Software Quality Journals	3	2	4	6		6		8		
IJHCI	2	2	3	5		3	5	6	5	1
Journals of Usability studies	2	5	4	3	5	9	8	13	8	
IJCSE		4	6	7		5	3	11	8	1
IJMCHI		2	6	4	3	7	7	9	12	2
CHCI	4	1	4	4	7	7	7	22	8	
IJCSI		1	3	5	5	3	1	12	7	1
Otherhi Journals	2	1	3	6	5	8	12	15	12	1
ACM	5	3	1	3	3	9	10	12	22	1
IEEE	3	1	-	2	10	9	12	16	12	2
Total	21	22	34	45	38	66	62	124	94	9

Learnability: This dimension refer to the effort that needed to be put by the user in learning the application without any difficulty (Seffah *et al*., 2006; Harrison *et al*., 2013; Madan and Dubey, 2012). Memorability measures the time taken in learning the interface of an application. Hearing impaired is commonly known as slow learner thus the complex interface would complicate the process of learning and memorizing the flow of the system (Lee *et al*., 2005; Villani, 2007; Zhou *et al*., 2012). While measuring learnability satisfaction in the menu and output displayed should be consistent and enable for user to learn easily and successfully finish the task in an application. Generally, learnability is about ensuring the reach of a particular goal in an application with less hassle (Seffah *et al*., 2006). Integrating level of memorability and consistency of an application would determine the degree of effort needed for the hearing impaired to learn the interface and use it gracefully.

Accessibility: Accessibility is most commonly known term for application development for disabled and contribute to this studies much closer since the model addressing hearing impaired people specifically. Accessibility also will assure people from different disabilities benefited and make the product more usable under many circumstances (Kim *et al*., 2014; Mohid and Zin, 2010; Paneels *et al*., 2013). The content in the application that meant to serve hearing impaired should

take care on the accessibility level of hearing impaired. Lesser audio cue and more animation into the content lead towards more assessable application (Yeratziotis and Greunen, 2013; Mohid and Zin, 2010; Efthimiou *et al*., 2006; Efthimiou and Fotinea, 2007; Mutalib and Maarof, 2010; Korte *et al*., 2012). Content would address user goals and whether the content of the application has the value towards the application or not (Yeratziotis and Greunen, 2013; Korte *et al*., 2012). Guidance for user is another important accessibility features should be measured since hearing impaired may need more help in using an application especially if the application more prone into audios. Instead of having third party guide, application should come with easy guide that allow meaningful usage of the application (Seffah *et al*., 2006; Harrison *et al*., 2013). It will also determine the support that application has for disable user, especially when the application is meant for hearing impaired. Navigation should be simple and easy to move around in the application for user to find content easily. This is also determined the level of understand ability about an application by the user, since the hearing impaired concerned as a slow learner. Thus, easy and simple navigation determine the full usage of an application without much frustration (Baharuddin *et al*., 2013; Madan and Dubey, 2012). In the navigation, simplify of the navigation will be investigated. It will determine the easiness in finding information as user requires and leaves satisfaction for them.

Satisfaction: Flexibility of a product determines the satisfaction of the user. It is very much important since it is pleasant feeling that's been attained by the user through the application usage (Madan and Dubey, 2012). Task presentation and functionality of the application will measure the satisfaction of the user towards the hearing impaired application. A design that has simple graphic, video presentation and captioning would enable a high satisfaction level of hearing impaired, since, they are more prone towards animation instead of full text form. Once the design is accurate and simple as required by the hearing impaired, it would be easier in engaging the user in the application. Engaging design contributes towards more attractiveness. Attractiveness towards the design would make user to be engaged and happier in using the application on a frequent basis. It will contribute in determining pleasing of the interface for the hearing impaired such as satisfaction with the virtual keypad, touch screen, navigation and help menu easier to be found and use (Hussain, 2012). Besides that, attractiveness will also use in determining the familiarity of the user towards the interface since hearing impaired easily attract to easy interface (Alsumait and Osaimi, 2009; Chittaro *et al*., 2006). Besides that hearing impaired people also looking for a simpler way of doing things, so that, it is understandable by themselves and other hearing people (Villani and Wright, 2007). The combination of these would enable measuring satisfaction levels of an application interface between the hearing impaired users for an application.

CONCLUSION

Usability measurement is a key factor in developing successful products to the user. In this case, the user is special need people and their requirements need to be enhanced and studied so that usability problems faced by this community can be identified and rectified. This paper aimed at presenting a systematic review on past studies and identifying usability dimensions that was needed for the development of a usability model for deaf mobile application interface evaluation process. This ensures that usefulness of the mobile application developed for deaf people are based on the requirements and focused on their need. This study contribute towards enhancing the usability of mobile applications for deaf. Relevant journal articles were reviewed carefully and considered for reviewing. As for the next stage of the study, metrics will be developed. The usability dimension and criteria derived will be used for verification through chosen usability experts for the originality and relevancy purpose.

ACKNOWLEDGEMENT

Researcher would like to thank to Universiti Utara Malaysia, particularly Research Management and Innovation Center for support and funding.

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