International Journal of Engineering & Technology, 7 (4.19) (2018) 369-373

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Accessibility, Disability and Deaf: a Review

Shelena Soosay Nathan[1*], Mazniha Berahim[2], Rosni Ramle[3], Azham Hussain[4], Nor Laily Hashim[5], Ansa Qurat-Ul-Ain[6]

[1, 2, 3] Universiti Tun Hussein Onn Malaysia
[4,5]Human-Centered Computing Research Lab, School of Computing, Universiti Utara Malaysia, Kedah, Malaysia
[6]University of Punjab, Pakistan
**Corresponding Author E-mail: [1]shelena@uthm.edu.my*

Abstract

Usability is an important attribute that needs more concentration in determining the production of a successful mobile application. Currently, deaf people has increased using mobile and the application tremendously. However, accessibility being under measured as many disability applications are being left unused after quite some time. To better suit the need of mobile applicationsfor the disability people, the level of accessibility needs to be measured accordingly. This study uses Systematic Literature Review (SLR) to review accessibility needs for a disability people application especially deaf people mobile application. Result from SLR shows that accessibility for mobile application for the deaf are measured limited in terms of its usage among deaf people due to lesser appropriate needs incorporated. This study helps mobile developers and evaluators in evaluating mobile application for the deaf by ensuring the accessibility are measured accordingly.

Keywords: *accessibility, deaf, disability, usability, mobile applications, evaluation*

1. Introduction

According to Malaysia Disability Act Policy, accessibility is regarded as equality to the disabled person such as at public amenities, facilities, education and technology. Accessibility assures people from different disabilities to benefit and make products more usable under many circumstances [5, 6, 7]. For the context of this study, accessibility for technology is highlighted. Utilisation of technology should not be biased for disabled people [2]. Technology lowers the barriers confronted by disabled people [4]. Accessibility is one of the main features of application related to any disability. Each device and technology-enhanced application is developed to offer accessibility as well as information assessment for the disabled people. According to Web Accessibility Initiative (WAI), accessibility is the facility in the web to be handled easily by disabled people regardless of their disabilities. Accessibility for mobile devices is about how a disabled person adapts and uses the device easily [11].

Accessibility features link closely with universal design which is a model to design something for the usage of all people [5, 8] using seven principles [9]; equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, size and space for approach and use.Equitable for use is about how the design should be useful and marketable to any group of users [9]. Flexibility in use focuses on design which accommodates a wide range of individual preferences and abilities. Simple and intuitive use is more on enabling the easy to understand design. Perceptible information refers to a design that communicates necessary information effectivelyto the user. Tolerance for errors is described as a design which minimises hazards and adverse consequences of accidental or unintentional actions. Low physical effort guides on a design to be used efficiently, and comfortably.

Finally, size and space for approach and use guideline determines the appropriate size and space provided for approach and usage.

Accessibility normally is depicted to address all disabled people in common [1]. For disability and precisely deaf people, universal design might not be an excellent choice for all technology development [10, 11]. This is because a universal design often addresses the principle for disabled people in accessing public amenities and it differs in many aspects to be adapted for technology development [10]. Besides that, as the name implies, the principles are for universal usage. Thus, some principles are meant for other disabilities, may not be proper for the deaf specifically [12]. Special principles or requirements need to be considered for deaf application. The author argued that accessibility has to be included during the development process itself to avoid ineffective usage of an application by the deaf due to low records of application used by these deaf people [3]. Evolution of technology intended for the disabled should be aligned with the accessibility guidelines. Therefore, accessibility guidelines to develop an application, especially for disabled people should be given more consideration and importance to enable these applications to be usable. This paper will be focusing on the need of accessibility in deaf mobile application and how it can be applied in measuring the usefulness of the application for the deaf people.

Section two of this paper review the accessibility for the deaf while section three discusses on the review on the deaf mobile applications while concluded with discussion.

2. Review on Deaf Accessibility

This section discusses on the papers being reviewed on deaf accessibility. A study by [13] investigates the accessibility importance in mobile application through Mobile Web Best Practises (MWBP) guidelines in testing. The MWBP guidelines assist developers on application development for disabled people through

testing conducted with related users [14]. The testing would enable identification of accessibility issues faced by disabled users and enhancements in application accessibility needed since different disability need different accessibility in application usage.

Mobile applications have become useful tools for many disabled people. But, not all are deaf-friendly. For example, certain deaf users need to adjust volume or coupling audio outputs [7] while other deaf users may choose to combine visual display technology to assist them to utilise a product [15]. This is because the limitation usage of certain audio or video might not be able to handle the disparity faced by the deaf. Thus, requirements for a highly discoverable content of technology by the deaf led to research on development of deaf technology with the proper usage of audio and video [12, 16, 17, 18, 19]. Deaf accessibility can be increased by providing auditory information visually, providing captions with multimedia and assigning a video signal for any audio output [19].

Requirements and needs of the deaf need to be focused on before development of technology to improvise the use of a product. The next subsection provides detailed description of the functionalities and requirements of deaf application. Table 1 shows the synthesis, analysis and criticisms on the literature discussed previously.

Table 1: Reviews on Accessibility from literature

Author	Synthesis	Analysis	Critics
[1, 3]	Accessibility in public amenities and technology for disabled.	• Accessibility for mobile application is about how the disabled person adapts and uses the application easily. • Needs to be included in the development process.	Accessibility is normally seen as a design for the disabled only whereas disability consists of many types and each differs in terms of its accessibility.
[5, 6, 7]	Courseware development for the deaf is implementing towards more accessible requirement needs and in need of ensuring fulfilment of developed technology.	• Assures people from different disability to benefit and makes products more usable under many circumstances.	Each disabled person needs technology that assures the level of usage instead of standardising the universal design.
[9, 10, 11]	Applying universal design for technology development especially mobile.	• Universal design might not be an excellent choice for any technology development.	Differs in many aspects to be adapted for technology development especially when user is disabled.
[16]	Development of principles to be included in the development of applications for the deaf.	• Some general principles might not be proper for the deaf.	Properly developed and verified model to ensure usability of mobile application evaluation for the deaf
[12]	Heuristic evaluation for deaf web user experience was conducted to identify the accessibility need of the deaf using web based applications	• Usability inspection method was applied to measure accessibility besides usability common evaluation • Enable to identify some important aspects of design that will impact the Web user experience for the deaf.	The accessibility feature needs has been emphasised which contributes towards usage of any application easily by the deaf that should be given more importance.

Table 1 shows that many studies agreed on common understanding of accessibility dimension needs especially on deaf applications. This leads towards more opening on the accessibility that has been constantly adapted into applications in general and not specifically although selected applications developed for specific disabled people. This also shows that previous studies are more concerned in applying the accessibility according to the disability of user for selected applications.

Many usability models do not consider accessibility dimension in evaluating an applications since most of the applications are developed for general usage. Ignorance of accessibility in applications for the disabled is another reason why the applications are not used by the user. Ensuring usefulness of a deaf application should include accessibility features to be evaluated for the usability of an application is important.

3. Review on Deaf Mobile Applications

This section will discusses on the deaf mobile application specifically and the common as well as difference in the application compared with common applications. 90% of deaf respondents agree that if there are effective instruments that aid in communication between the deaf and normal people, they will be useful [46]. According to [25], mobile technology is a great help for the deaf whereby it provides knowledge verbally and better learning experiences. The primary goal of their study is to help deaf students in utilising mobile technology for their daily life tasks and learning functions. Thus, Mobile Technologies in Deaf and Hard-Hearing Persons (IBEM) was introduced as an instructional technology in the school. The authors use multidimensional assessment model derived from [31] which consists of four dimensions; task, individual, context and device. They evaluated the application in all four dimensions and found that multimedia content make technology for the deaf more usable since the participants are able to understand easily and respond to the technology. Their study focuses on the development and evaluation of an application. However, usability is not the main issue being discussed. More importance was given to the participants to test their comfort level when using the application. The comfort level, accessibility level as well as application content play vital roles in determining the usability of any product [32].

Most deaf communicate through sign language, which is very different from normal spoken language [27]. However, not many people have knowledge in using sign languages, including the deaf themselves [28, 29, 30]. Hence, a communication barrier may exist between the deaf and normal people, and between the deaf themselves. The deaf mostly depend on the interpreter for sign language so that they can communicate with normal people.Researchers focus on developing sign language interpreter applications that aid both literate and illiterate deaf users which can help in one way or another to reduce this barrier and make the deaf part of society. However, studies mostly focused on sign language interpreter using external hand gloves [20, 21, 22, 23] which are regarded as expensive and non-usable by many deaf people [21].[24] consideredmany issues during the development of an Arabic sign language application such as portability, extensibility, ease of use and efficiency. The application was evaluated with six dimensions; efficiency, extensibility, performance, portability, reliability and usability. The application has limitations in terms of language since it is targeted at Arabic language users and hardwareas the mobile device used must have ahigh-resolutioncamera for proper translation of sign language. This means that mobile phone users with low resolution camera are neglected and somehow it does not show the effectiveness of the system [39, 36, 37].

Mobile game-based learning has been gaining traction in various discipline, including application for the disabled. [40] developed a game based mobile application for deaf children named MOGAT and tested it using three dimensions; naturalness, motivation and

enjoyment. The application basically did not fully address the needs of the deaf. Dimensions such as accessibility [16], effectiveness and efficiency could have increasedthe acceptability of the application [41, 42]. [43] developed mobile gamejFakih that are targeted for deaf children learning Jawi through hand sign. Usability testing was conducted where Nielsen model [42] was used as a basis and additional dimensions were added which consist of eleven dimensions altogether. They are error, ease of use, help, user enjoyment, system performance, game level, navigation, user friendliness, efficiency, memorability and learnability. The study suggests using different models and methods for usability testing of application to better serve the needs of deaf children.[47] studied the challenges faced by deaf children in their daily schooling activities where education-based games has generated meaningful learning experience. A model to assess game quality has been designed to examine whether the gameimprove the deaf children's reading and writing skills. Usability test with five dimensions;effectiveness, efficiency, satisfaction, emotion and learning were conducted through a questionnaire to assess the experience of using the game. The evaluation discovered that the application faces issue in rendering help as there are no feedback for mistakes made and different vocabulary provided confuses users. However, the evaluation does not integrate accessibility features for the deaf to be tested in which the author agrees that it is necessary to identify their requirement [12].

[13] investigate the importance of accessibility in mobile application by including MWBP into the testing which is a guideline to provide support for content delivery accessible for disabled people important to establish a guide for developers of application for the disabled [14]. Result shows that the guideline available must be documented clearly and indicatedthe need to enhance existing guideline like MWBP to support mobile application's accessibility. Thus, a mobile application that aligns with accessibility can be used to identify usability issues effectively as one of the needs of deaf users.

[44] also adopted the Nielsen modelin the usability testing for PekAR, a learning courseware for the deaf using augmented reality. Since there is no specific usability model, heuristic evaluation is thus chosen to have a clear view on the design of the application. Testing the usability of an application needs to consider many attributes to ensure the application is suitable and useable [38, 41]. However, this study did not cover the usability testing on the application's interface. This could have been due to the unavailability of proper guidelines for conducting a usability evaluation [49,50]. The usability evaluation, however, seem to be generalised. Besides that,Courseware are given importance in terms of learning attributes and neglected in terms of users' satisfaction [44, 45]. However, the similarities between usability testing of the deaf courseware applications is that the studies focus on user testing, implemented ISO 9241-11 and Nielsen model which shows a specific model for deaf usability evaluation of application is unavailable.

[33] conducted a case study on iPhone applications usage among the deafand found that many deaf in Qatar are using mobile phones like the ones used by hearing people as it enables themto communicate much easier with applications such as chatting, maps, multimedia messages, video calls and internet browsing. Survey on satisfaction together with interviews regarding the applicationswere conducted and received positive remarks.No focus was given to study the usability of the application. [48] measures the usability of a mobile application "Voice Communication" which enable communication between two disabled people. The application supports speech to text and text to speech messaging services to ease communication of the deaf with others. The application was tested in terms of performance and functionality through the time taken to use the application as well as observation on how the application is being used. Overall impression of the interface easiness was also tested to ensure interface is understandable and attractive for the deaf. 12 criteria were evaluated; accuracy, speed, completeness, independency, time response, clarity, uniqueness, usefulness, user friendliness, navigation, reliability and easiness. Evaluation found that the deaf respondents are satisfied with the conversion of speech to text and they agree that the application enables them to communicate easily. But the application lack testing in terms of other accessibilities that are needed by the deaf such as alert functionality [12]. Besides, efficiency of the real time voice command should also be tested.

[34] conducted a mobile application testing for visually-impaired people where accessibility and usability of application for disabled people were discussed. Even though [13, 34, 35] test the applicability of application for the disabled, they lack proper guidelines for usability testing. These studies have only utilised user testing to gain performance rate level, but a proper usability model to test the usage rate of the application interface would add validity of the application [36, 37, 38]. More convincing usability issues could have been reaped with usability model during an evaluation [36, 38].

Table 2: Reviews on Tested Deaf Applications

Application	Usefulness Tested
Mobile Technologies in Deaf and Hard-Hearing Persons (IBEM) [25]	task, individual, context and device
Arabic sign language usability	efficiency, extensibility, performance, portability, reliability and
MOGAT [40]	naturalness, motivation and enjoyment
jFakih [43]	error, ease of use, help, user enjoyment, system performance, game level, navigation, user friendliness, efficiency, memorability and learnability
PekAR [44]	heuristic evaluation
Voice Communication [48]	accuracy, speed, completeness, independency, time response, clarity, uniqueness, usefulness, user friendliness, navigation, reliability and easiness

Table 2 summarized the review above which shows that some of the reviewed deaf application has been tested before roll out for usage however accessibility features are not been tested in any of those application. Though the researchers have highlighted importance of the accessibility in any disabled application, these deaf application unable to identified proper accessibility measurement in any of these applications. As such, the need of accessibility has been overlooked in deaf application that need to be identified and tackled to ensure completeness of an application for the deaf people.

4. Conclusion

Literature review found that research conducted on the deaf application is very limited. Many studies focused on e-learning for the deaf [24, 25, 26], which are too general in terms of application development as well as evaluation conducted. Most researchers conducted usability testing with general usability criteria such as effectiveness, efficiency and satisfaction which are not capable to meet certain requirements for deaf people, especially when it is for a mobile application [36, 37, 41], where mobile application limitation such as platform compatibility [37] also needs to be consideredsince the application is to be used on mobile devices [36, 37, 38]. Most testinghad not evaluated much on deaf accessibility which is an important feature for deaf mobile application functionality [12]. Only by measuring the specific features of the application would enable it to be classified useful for the targeted user. Any application related to the disability especially deaf people are in need of appropriate accessibility measured. Then only will those application be able to fulfil the real need of the disability and ensure continuous usage.

Acknowledgement

The authors would like to thank Research Management Center of Universiti Tun Hussein Onn for the financial support rendered through Tier 1 (H145) grant scheme and Universiti Utara Malaysia as well as University of Punjab, Pakistan for their collaboration in the literature works.

References

[1] S. K. Kane, C. Jayant., J. O. Wobbrock., & R. E. Ladner. Freedom to roam: a study of mobile device adoption and accessibility for people with visual and motor disabilities. In Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility, ACM,2009, pp. 115-122.

[2] A., Asch. Reproductive technology and disability. In Reproductive Laws for the 1990s, 1989, pp. 69-124, Humana Press

[3] J. Abascal., S. D. Barbosa., C. Nicolle., & P. Zaphiris. Rethinking universal accessibility: a broader approach considering the digital gap. Universal Access in the Information Society, 2016, 15 (2), pp. 179-182.

[4] A. Juozenas., P. Kasparaitis., K. Ratkevicius., D. Rudinskas., A. Rudzionis., V. Rudzionis., & S. Sidaras. DfA implementations for people with vision and hearing disabilities: application and development for information society. In International Conference on Universal Access in Human-Computer Interaction, 2007, pp. 686-695.

[5] H. Kim., & H. Song. Evaluation of the safety and usability of touch gestures in operating in-vehicle information systems with visual occlusion. Applied ergonomics, 2014, 45(3), 789-798.

[6] S. A. Panëels., A. Olmos., J. R. Blum., & J. R. Cooperstock. Listen to it yourself: evaluating usability of what's around me for the blind. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2013, pp. 2107-2116.

[7] S. M. Zaharah., & M. Z. Norazan. Courseware Accessibility for Hearing-impaired. In Proceedings of International Symposium in Information Technology, 2010.

[8] O. Plos., &, S. Buisine. Universal design for mobile phones: a case study. In CHI'06 Extended Abstracts on Human Factors in Computing Systems, 2006,pp. 1229-1234.

[9] S. A. Kadir., & M. Jamaludin Applicability of Malaysian standards and universal design in public buildings in Putrajaya. Procedia-Social and Behavioral Sciences, 2012, 36, 659-669.

[10] S. Burgstahler. The role of technology in preparing youth with disabilities for postsecondary education and employment. Journal of Special Education Technology, 2003, 18(4), 7-20.

[11] M. Rowan., P. Gregor., D. Sloan., & P. Booth. Evaluating web resources for disability access. In Proceedings of the Fourth International ACM Conference on Assistive technologies, 2000, pp. 80-84.

[12] A. Yeratziotis., & P. Zaphiris. A Heuristic Evaluation for Deaf Web User Experience (HE4DWUX). International Journal of Human–Computer Interaction, 2017.

[13] R. Bandeira., R. Lopes., & L. Carriço., Towards mobile web accessibility evaluation. Free and Open Source Software for Accessible Mainstream Applications (FOSS-AMA), collocated with ETAPS, 2010, 27-28.

[14] B. Kelly., L. Phipps., & E. Swift. Developing a holistic approach for e-learning accessibility. Canadian Journal of Learning and Technology, 2004, 30(3).

[15] J. Beskow., O. Engwall., B. Granström., P. Nordqvist., & P. Wik. Visualization of speech and audio for hearing-impaired persons. Technology and Disability, 2008, 20(2), 97-107.

[16] G. Yeratziotis., & D. van Greunen. Making ICT accessible for the deaf. In IST-Africa Conference and Exhibition (IST-Africa), 2013, pp. 1-9.

[17] J. Korte., L. E. Potter., & S. Nielsen. Designing a mobile video game to help young deaf children learn Auslan. In Proceedings of the 26th Annual BCS Interaction Specialist Group Conference on People and Computers, British Computer Society, 2012, pp. 345-350.

[18] E. Efthimiou., E. Fotinea., & G. Sapountzaki. E-accessibility to educational content for the deaf. European Journal of Open, Distance and E-Learning, 2006.

[19] E. Efthimiou,. & S. E. Fotinea. An environment for deaf accessibility to educational content, In Proceedings of the 1st International Conference on Information and Communication Technology and Accessibility, Hammamet, Tunisia, 2007, pp. 125–130.

[20] P. Pandey., V. Jain., & C., G., Bhilai. Hand gesture recognition for sign language: a Review. International Journal of Science, Engineering and Technology Research (IJSETR), 2015, 4(3), 464–470

[21] A. S. Ghotkar., & G. K. Kharate. Study of vision based hand gesture recognition using Indian sign language. International Journal on Smart Sensing and Intelligent System, 2014, 7 (11), 96-115.

[22] P. S. Rajam., & G. Balakrishnan. Real time Indian sign language recognition system to aid deaf-dumb people. In Communication Technology (ICCT), IEEE 13th International Conference on IEEE, 2011, pp. 737-742.

[23] T. Shanableh., K. Assaleh., & M. Al-Rousan. Spatic-temporal feature-extraction techniques for isolated gesture recognition in Arabic sign language. Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions, 2007, 37(3), 641-650.

[24] F. Al Ameiri., M. J. Zemerly., & M. Al Marzouqi. M-learning and chatting using indexed Arabic sign language. International Journal for Infonomics (IJI), 2012, Volume 5, Issue 1/2.

[25] C. Çuhadar., H. F. Odabaşı., & A. Kuzu. M-Learning for hearing-impaired learners: Dimensions of evaluation. International Journal of Education and Information Technologies, 2009, 3(3), 179-186.

[26] N. Adamo-Villani. A virtual learning environment for deaf children: design and evaluation. International Journal of Human and Social Sciences, 2007, 2(2), 123-128.

[27] M. Wheatley., and A. Pabsch. Sign Language Legislation in the European Union, 2nd ed. Brussels: European Union of the Deaf, 2012.

[28] M. Boulares., & M. Jemni. Mobile sign language translation system for deaf community. In Proceedings of the International Cross-Disciplinary Conference on Web Accessibility, ACM, 2012, p. 37.

[29] Z. A. Shaffiei., & N. Aziz. Assistive courseware for hearing-impaired learners in Malaysia based on theory of multiple intelligences (MI). International Journal of Computer Science & Emerging Technologies, 2012, 2(6).

[30] W. X. Fen., & X. J. Cheng. Using mobile learning way to support learning of the deaf. In Education Technology and Computer (ICETC), 2nd International Conference on IEEE, 2010, Vol. 2, pp. V2-460.

[31] D. P. Bryant., & B. R. Bryant. Assistive technology for people with disabilities. Pearson Higher Ed., 2003.

[32] K. A. Weaver., & T. Starner. We need to communicate!: helping hearing parents of deaf children learn American Sign Language. In the proceedings of the 13th international ACM SIGACCESS Conference on Computers and Accessibility, ACM, 2011, pp. 91-98.

[33] R. S. Hassan. Mobile communication for people with disabilities: A case study on iPhone technology usage for deaf and mute Qatari adults. International Congress on Communication, 2011, 5, 587-596.

[34] M. A. Sánchez., M. Mateos., J. A. Fraile., & D. Pizarro. Touch Me: a new and easier way for accessibility using Smartphones and NFC. In Highlights on Practical Applications of Agents and Multi-Agent Systems, Springer Berlin Heidelberg, 2012, pp. 307-314.

[35] M. Kipp., A. Heloir., & Q. Nguyen. Sign language avatars: animation and comprehensibility. In Intelligent Virtual Agents, Springer Berlin Heidelberg, 2011, pp. 113-126.

[36] R. Harrison., D. Flood., & D. Duce. Usability of mobile applications: Literature review and rationale for a new usability model. Journal of Interaction Science, 2013, 1(1), 1-16

[37] A. Hussain. Metric based evaluation of mobile devices: mobile goal question metric (mGQM). (Doctoral Dissertation). University of Salford, United Kingdom: UK, 2012.

[38] C. K. Coursaris., & D. J. Kim. A meta-analytical review of empirical mobile usability studies. Journal of Usability Studies, 2011, 6(3), 117-171.

[39] K. Moumane., A. Idri., & A. Abran. Usability evaluation of mobile applications using ISO 9241 and ISO 25062 standards. SpringerPlus, 2016, 5(1), 548.

[40] Y. Zhou., K. C. Sim., P. Tan., & Y. Wang. MOGAT: mobile games with auditory training for children with cochlear implants. In Proceedings of the 20th ACM International Conference on Multimedia, ACM, 2012, pp. 429-438.

[41] R. Baharuddin., D. Singh., & R. Razali. Usability Dimensions for Mobile Applications-A Review. Research Journal of Applied Sciences, 2013, 5(6), 2225-2231.
[42] J. Nielsen. Heuristic evaluation. Usability Inspection Methods, 1994, 24, 413
[43] A. Hussain., N. A., Mutalib., & A. Zaino. A usability testing on JFakih Learning Games for hearing impairment children. In Information and Communication Technology for the Muslim World (ICT4M), The 5th International Conference on IEEE, 2014, pp. 1-4.
[44] N. M. M. Zainuddin., H. B. Zaman., & A. Ahmad. Heuristic evaluation on augmented reality courseware for the deaf. In User Science and Engineering (i-USEr), International Conference on IEEE, 2011, pp. 183-188.
[45] A. K. Masitry., M. A. Majid., M. Z. Toh., & T. Herawan. An investigation on learning performance among disabled people using educational multimedia software: A case study for deaf people. International Journal of Bio-Science & Bio-Technology, 2013, 5(6).
[46] D. Nashat., A. Shoker., F. Al-swat., & R. Al-ebailan. An android application to aid uneducated deaf-dumb people. International Journal of Computer Science and Mobile Applications, 2014, 2(9), 1–8.
[47] S. Cano., J. M. Arteaga., C. A. Collazos., & V. B. Amador. Model for analysis of serious games for literacy in deaf children from a user experience approach. In Proceedings of the XVI international conference on human computer interaction ACM, 2015, p. 18.
[48] J. A. Landicho. Voisee Communicator: An Android Mobile Application for Hearing-impaired and Blind Communications. International Journal of Interactive Mobile Technologies (iJIM), 2016, 10(4), 26-31.
[49] S. S. Nathan, A. Hussain, N. L. Hashim. Studies on deaf mobile application. AIP Conference Proceedings 1761, AIP Publishing.
[50] S. S. Nathan, A. Hussain, N. L. Hashim. Deaf mobile application accessibility requirements. AIP Conference Proceedings, AIP Publishing.
[51] S. S. Nathan, A. Hussain, N. L. Hashim. Studies on Deaf Mobile Application: Need for Functionalities and Requirements. Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 8(8), 47-50.