Requirements of Enjoyable Mobile Learning Applications for Deaf Children

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ABSTRACT

In the domain of mobile learning applications for deaf children, many studies are more concerned with the development of mobile learning applications for deaf children than with determining what makes them enjoyable for this group of children. Some of these learning applications do not meet the needs of deaf children for learning since the requirements were not collected from the actual deaf children. As a result, many deaf learning applications are still not gaining much popularity among people who are deaf or hard of hearing due to the

application due to the applications' inability to meet their expectations and needs. Hence, this paper aims to identify the requirements for designing an enjoyable mobile learning application for deaf children. In achieving this goal, it is essential to identify the requirements of deaf children on mobile learning applications from their own everyday experience and support these identified needs with requirements gathered from their parents and teachers and literature. Three methods were conducted for this study to identify and synthesise these requirements: (1) Fun Sorter data collection method was conducted among the deaf children, whose ages are between 7 and 12 years old; (2) an interview involving teachers and parents of deaf children; and (3) a literature review on deaf children's learning. The identified requirements were verified through a focused group attended by eight mobile learning developers. The finding identified six requirements: multimedia elements, games, easy-to-use, simple tasks, guidance, and alerting. These requirements serve as crucial guidelines for mobile app developers, enabling the creation of enjoyable learning applications designed specifically for deaf children. Furthermore, these requirements can potentially improve the learning journey of deaf children, offering them valuable benefits and enhancing their educational experiences.

INTRODUCTION

An enjoyable mobile learning application has a fun element in technology education that motivates the participants (Pienimäki et al., 2021). Mobile learning applications are more accessible for children since they can self-learn after school hours and progressively use mobile devices, significantly benefiting deaf children (Marschark & Spencer, 2016). A study in German Sign Language among deaf children ages 4–11 found that deaf children had difficulties controlling the mouse in desktop applications. They preferred completing tasks given on paper to point out the answers (Haug, 2014). Thus, mobile devices with touch screens will make deaf children feel more able to interact with the learning application using their fingers (Marin et al., 2019).

The requirements for mobile learning applications may differ depending on the types of disabilities. For example, in the field of

Human-Computer Interaction (HCI), disabilities are frequently classified as perceptual (hearing and visual impairments), physical (constrained use of hands, arms, and speech), and cognitive impairments (Lazar et al., 2017). Moreover, the deaf is classified into three categories: (1) deaf only; (2) deaf and non-verbal; and (3) deaf with disabilities (Department of Social Welfare of Malaysia, 2020). These classifications are based on functional requirements relating to mobile learning application outputs and inputs, which means that people with perceptual impairments will be affected by mobile learning outputs, while people with physical impairments will be affected by mobile learning inputs (Lazar et al., 2017). In light of these classifications, it is essential to consider how mobile learning applications are tailored to meet varied needs, especially for deaf people.

Moreover, as the Department of Social Welfare Malaysia (2020) reported, the number of deaf children registered increases yearly. A deaf child is a user who cannot listen or talk. Despite their limitations, deaf children are eager to utilise mobile phones and applications that have become commonplace in recent years (Bitar et al., 2021). In addition, Yeratziotis and Zaphiris (2018) claimed that current mobile learning applications for deaf children are less frequently utilised. Hence, this community should not be left behind to get the same benefits as normal children, especially for learning purposes.

By using mobile learning applications, deaf children can enjoy learning and revising wherever they are, in addition to enhancing their achievement of the lesson (Mohamad & Hashim, 2021). They also claimed that enjoyment is proven to reduce boredom among deaf children and improve their effectiveness. Several studies were conducted on deaf mobile applications (Samsudin et al., 2018; Tovide et al., 2022). However, most of them concentrated on mobile application development for deaf people but not on deaf learning. On the other hand, the requirements proposed by Nathan et al. (2018) are more suitable for sign language mobile applications for communication purposes among adults. Furthermore, they do not focus on the enjoyable aspects, and the requirements are not gathered from the actual deaf children. Besides, they have never been tested on mobile learning applications. Thus, this study will focus on gathering requirements for mobile learning applications for deaf children. It is to ensure that the mobile learning application meets the needs of deaf

children for learning. Furthermore, deaf children can study the same topics as hearing children, even though they must learn at home.

Many techniques are considered for requirement gathering, such as interviews, surveys, and brainstorming (Zachariah & Nonyelum, 2020). However, a technique called the Fun Sorter (FS) toolkit has been introduced by Read and MacFarlane (2006) as a data collection method suitable for gathering opinions among children during a survey. FS is a fun toolkit technique used in this study to gather requirements among deaf children for using mobile learning applications. Through FS, deaf children can rank the mobile learning applications based on their enjoyment and the ones that are easiest to do. The children can choose the best application based on their favourite activities. Thus, this study has applied this method to capture which elements make deaf children have fun using the given mobile learning applications and find them easy to handle. Likewise, Molnár (2018) claimed that teachers' and parents' views are vital when designing enjoyable mobile learning applications for deaf children. Hence, an interview is also chosen to gather information about the requirements from teachers and parents of deaf children.

This paper seeks to identify the requirements for creating engaging mobile learning applications tailored for deaf children. This paper has four main sections. The first section presents an introduction to the topic, followed by a section on related work. The third section highlights the method used, and the fourth section presents the results and discussion. Finally, the paper draws an overall conclusion to the study.

RELATED WORK

This section covers past studies regarding the requirements of mobile learning for deaf children. Besides that, methods to gather requirements, the rise of the need to investigate enjoyment in a mobile learning application and some examples of mobile learning applications are also briefly explained in this section. Several studies have highlighted requirements related to mobile learning applications. According to Bragg et al. (2015), visuals play an important role in the deaf learning process since deaf people require visuals to experience sound and improve their grasp of what is communicated to them. They

also studied sign language dictionaries, and these applications are still inadequate in terms of sign language usage, the lack of speech, and animation. The visual aspect is also highlighted in a study conducted by Yousaf et al. (2018). They produced guidelines for the development of deaf applications where they highlighted important features for this application, such as visual and vibrating alerts or notifications, adjustable volume control, messaging options, and a tactile indicator on the keyboard that is specifically for deaf people, are highlighted as essential requirements to be considered. These requirements are compiled for both desktop and mobile applications. An additional requirement was proposed by Al-Megren and Almutairi (2019); they found that captioning is given more importance since video and other audio-related files could be easily interpreted by deaf people (Al-Megren & Almutairi, 2019). Besides that, their findings also indicated that signed video would benefit deaf people for navigational purposes and provide an easily understandable user guideline. In addition to that, other essential requirements in assistive technology for deaf people are navigation, sign language, and the flow of content (Mutalib et al., 2016). Based on their observations, technology should be more straightforward, with more visuals, fewer sounds, and optimum colour contrast to engage deaf children in technology. Consequently, the above studies provide insights into identifying and discovering the requirements of mobile learning applications for deaf children, which can be used as a reference in this study. The following paragraph discusses the techniques employed to collect these requirements.

Researchers used different methods in this domain to gather requirements related to mobile applications for deaf people. Studies by Mutalib et al. (2016), and Shelton and Parlin (2016), gathered these requirements through three phases: user requirement study, prototype development, and observation study. They attempted to create a prototype to help deaf children, and evaluation was done through observation. In their study, Yousaf et al. (2018) used literature reviews, interviews, and the FS method. This discussion on methods used in requirement gathering suggests suitable methods to be adopted in conducting this study.

The subsequent research examines various aspects within the same field, even though with a slight variation in focus, specifically targeting adult participants for developmental purposes rather than concentrating on educational applications. Nathan et al. (2018)

studied mobile applications for the deaf community. They have proposed some requirements, but the requirements are more suitable for communication than learning. On the other hand, many studies have focused on the development of mobile applications for deaf people (Samsudin et al., 2010; Shelton & Parlin, 2016; Mutalib et al., 2016; and Shelton & Parlin, 2016). However, they did not stress learning for deaf children. Also, enjoyable aspects are not stressed out by these studies. Hence, this study will focus on the requirements for enjoyable mobile learning for deaf children, which requirements are found in the responses of the actual deaf children themselves.

Enjoyment is an essential aspect of making a mobile learning application attractive for children (González-González et al., 2014). The application should be designed to be fun for children. This can be done using e-stories, games, role-play, and any other activities that can gain the attention of children and maintain their motivation (Latiff et al., 2019). Fun as a concept is widely recognised in the HCI community (Hassenzahl, 2003) as well as in the Child-Computer Interaction (CCI) community (Read & MacFarlane, 2006). Enjoyment, pleasure, fun, and attraction are widely used to address similar types of feelings (Hassenzahl, 2003). Enjoyment can be a reward in a learning experience (Sim et al., 2021) or a result of the play (Read & MacFarlane, 2006). Hence, a deaf children's mobile learning application can be considered enjoyable if it contains a fun element that draws the user's attention and encourages them to use it frequently. From the above discussion, enjoyment should also be considered as one of the requirements in the application.

There are some mobile learning applications for deaf children, such as KoTBaM, PopSignTest, and ABIM, that can be downloaded through the Google Play Store. These three mobile learning applications have applied some enjoyment elements, like games and simple tasks, to maintain the user's motivation. KoTBaM is an application that applies learning based on school topics, compared to ABIM, which does not focus on school topics. Furthermore, ABIM is a one-way communication system, which means that users can only view and learn the lesson. It can cause boredom for deaf children (González-González et al., 2014). Only KoTBaM provides an interpreter to translate the application's statement. Following that, PopSignTest is a learning game application that involves matching words with sign language. Deaf children can play while learning to match the word.

However, sign language evolves quickly. It makes it difficult for deaf children to catch up with the sign before they match the right word. As previously stated, even though they are only deaf, they do not learn as well as other children (Marschark & Spencer, 2016). Thus, requirements from KoTBaM, PopSignTest, and ABIM are used in the FS and ranked by the deaf children. These applications provide opportunities for learning, but they should be evaluated based on the requirements and preferences of deaf children to enhance their education.
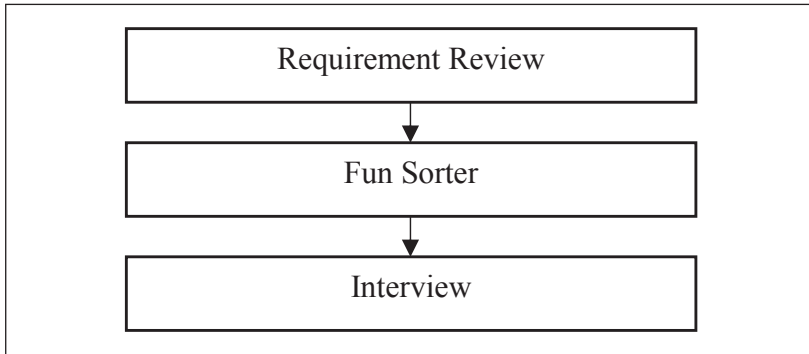
Based on the related work discussed earlier, many requirements were suggested and applied in previous studies that can be used in shortlisting the key requirements for mobile learning applications for deaf people. The abovementioned requirements are visuals, sign language usage, accessibility features like vibrating alerts and adjustable volume control, captions, and signed video. Researchers in this domain have applied different methods in gathering requirements, such as requirement analysis, prototype development, and observations. Several of these methods are used in determining the requirements in this study, which are elaborated on in the next section. This information could guide the researchers to apply similar choices of methods in gathering requirements from the deaf community. While some studies have explored mobile applications for the deaf community, there is a need for a focus on learning applications for deaf children, considering their enjoyment and engagement. Based on these findings and gaps identified from the literature review, this study will focus on extending identified requirements and tailoring them to create engaging mobile learning applications tailored for deaf children. This study will adopt methods of requirement gathering applied by Yousaf et al. (2018).

METHODS

Some methods are applied to identify requirements for enjoyable mobile learning applications for deaf children. The methods used are presented in Figure 1, and the content of this section is as follows: requirement review, FS, and interview. The results obtained through these three methods are matched with each other to come up with the requirement of an enjoyable deaf children's mobile learning application for verification through expert review.

Figure 1

Steps of Requirements Gathering

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│   │          Fun Sorter               │ │
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│   │          Interview                │ │
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Requirement Review

The objective of the requirement review is to match what was discovered in the FS and interview with what is needed. The analysis was carried out based on various sources to eliminate the exclusion of related studies. The articles included in this review are papers and publications related to deaf people. The keywords used in finding the associated articles were "deaf", "requirements", "mobile learning", "hearing-impaired" and "children", which were published from 2014 until 2022. The data is analysed to identify the requirements for deaf children's mobile learning applications.

Fun Sorter

An FS is used to get data from the actual deaf children. There are three steps involved in the FS, as illustrated in Figure 2, including preparing the fun sorter form, explaining it to teachers of deaf children and distributing the fun sorter form. This step began with giving an FS form to deaf children from Malaysian deaf schools. Since the COVID-19 pandemic, authors have been prohibited from interacting with deaf students in the classroom, and no photos or video recordings have been permitted. Fortunately, teachers of deaf children volunteered to collect data from their pupils. Three deaf learning applications for pupils aged between 7 and 12 years old have been chosen to be ranked by the respondents: KoTBAM, PopSign Test, and ABIM. These three learning applications were selected based on the content recommended by teachers of deaf children. Besides that,

the pupils are quite familiar with those applications since the teachers have suggested them for self-learning during the pandemic.

Figure 2

Steps Involved in FS
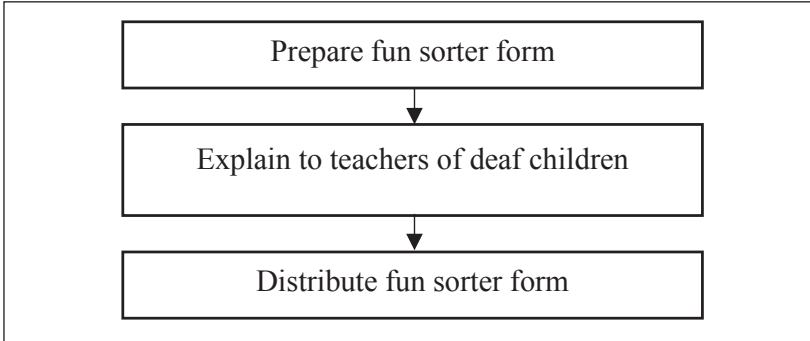
KoTBaM is a mobile learning application whose contents are based on deaf children's study of *Bahasa Melayu* at school in Malaysia. It has a video of sign language for every single word in a statement. Besides, a user manual is provided as a reference for users to use the application. The second deaf mobile learning application used is PopSignTest. It is a deaf mobile learning game in which users are required to pop the right balls according to sign language shown by a translator. The content concerns the *Bahasa Inggeris* subject that deaf children learn in school. The last deaf mobile learning application chosen for the fun sorter method was ABIM. ABIM uses sign language animation to teach simple words that are commonly used in daily communication. The features that are provided by these learning applications are listed in Table 1.

Table 1

Requirements Provided in Selected Mobile Learning Applications

Mobile Learning Applications	Requirements
KoTBAM	A user manual is provided in the main menu. Easy to understand Content follows the syllabus in school. Images and videos of sign language

(continued)

Mobile Learning Applications	Requirements
ABIM	Images of each sign language of the alphabet
	The animation sign language of verbs, pronouns, greetings, and days.
PopSignTest	Games to make the learning process fun.
	Simple tasks.
	Videos of sign language

The chosen learning applications will be numbered one, two, and three—number one for KoTBaM, two for ABIM, and three for PopSignTest. Since deaf pupils are slower than other children, recalling those learning applications is easier (Marschark & Spencer, 2016). The teacher explained this tagging number before the participants filled in the FS. The teacher selected the participants based on their familiarity with using mobile applications. Based on the selection, only thirteen pupils were chosen to be participants in this study. The authors provided two mobile phones for this session. These mobile phones were installed with the selected learning applications before being passed to the teachers. After using the mobile learning applications, participants were expected to write down the number of the mobile learning applications in the order of the most fun to the least enjoyable. It is also recommended by Siong et al. (2021) that the FS form be used at least two rows or two columns at a time to avoid children recopying them down to another form, as shown in Figure 3.

Figure 3

Example of Fun Sorter Form

After using the mobile learning applications, participants were asked to list the names of these apps and rank them based on how much fun they found them. They assigned a score of 3 to the most enjoyable and a score of 1 to the least enjoyable. To prevent the need for children to copy the names to another location, it is recommended to use at least two rows or columns simultaneously (Read, 2012). The collected data were then analysed, considering the scores assigned to the selected mobile learning games. The mobile learning application with the highest score was deemed to meet the requirements of deaf children. The FS method is used for ranking purposes and is unsuitable for direct comparison of different experiences, as Sim et al. (2013) explained.

Participants must rate the learning applications based on their level of fun and ease of handling after using the selected learning application by filling out the FS form. The goal of the FS conducted with deaf children is to understand the needs and experiences highlighted in selected mobile learning applications for this study. The rating has been divided into three scores ranging from one to three for analysis purposes. Based on the FS technique, a score of three indicates the most fun and easiest to do, a score of two indicates fun and easy to do, and a score of one indicates the least fun and most difficult to do. The application with the highest score will be chosen as the most enjoyable and easiest to complete the task, and vice versa (Read & MacFarlane, 2006). However, this study considers features in the first rank of learning applications as basic needs that deaf children express, followed by the second and third ranks. The calculation of the score has been explained in the next section. Requirements of the mobile learning application that are most fun and easiest to do are considered to be requirements chosen by deaf children.

Interview

On the other hand, interviews with teachers and parents of deaf children were also done to gather requirements. The interview session was held in a focus group before the Malaysian government announced the movement control order (MCO) during the COVID-19 pandemic. This technique has ensured that the needs of deaf children are addressed and highlighted in mobile learning applications designed exclusively for them. A few open-ended questions were used during the interview sessions. The interview questions were designed based on four categories: age and experience, behavioural

questions, technical questions, and opinions and recommendations. They were adapted from a study by Al-Megren and Almutairi (2019), suggested by Guzmán (2018), and modified based on the purpose of this interview.

Age and experience were covered under the background of the respondent. For teachers, teaching experience is also covered in this category. The behavioural question category is designed to elicit information about their experience as a teacher and parents of hearing-impaired children in the real world and the issues they encountered. Meanwhile, technical questions were asked regarding the interface and features of existing mobile learning applications for hearing-impaired children that the respondents used. Finally, the session ended with opinions and recommendations given to allow ideas, suggestions, or comments about existing and future mobile learning applications for hearing-impaired children. All the questions have been mapped in Table 2. It is part of the instrument development for an interview. The questions for the interview session were prepared as a reference during the interview session. Before the interview, the headmaster of *Sekolah Pendidikan Khas Pekak* (SKPK) Perlis checked the questions to ensure they did not touch on sensitive issues towards deaf children and their families. The interview will be done informally to enable a more relaxed situation and more space for deaf teachers and parents to share their thoughts openly. The interview question has been attached as an appendix.

Table 2

Mapping of Interview Questions

Category	Parents (No. of question as in the Appendix)	Teacher (No. of question as in the Appendix)
Age and experience	1	1,2
Behavioural question	2,3,4,5,6iii	2c,5
Technical question	6,6i,6ii,7,8,9	2A,2B,3,4
Opinion & recommendation	10,11,12	6,7,8

After collecting needs through interview sessions, the gathered comments from teachers and parents of deaf children are analysed to

define the requirements. The interviewees were asked to share their experiences and obstacles with deaf mobile learning for children during the session. Through interviews, deaf children's requirements have been identified, which has contributed to the development of mobile learning applications. The comments were analysed using qualitative data analysis software, and the comments were gathered according to nodes (recognised requirements) and matched to support the nodes. The nodes would later be employed to meet mobile learning application requirements for deaf children. The interviews with teachers and parents of deaf children provided valuable information and input on crucial criteria that should be included in the learning application. The interview questions contain basic screening questions, technical questions, behavioural questions, and suggestions or recommendations. The interview has been conducted informally to provide a more relaxed environment and more opportunities for deaf teachers and parents to express themselves honestly.

Requirement Verification

The experts verified the matched requirements from the FS, interview, and literature review. Verification is about determining whether the requirements meet the user's expectations and represent the real world from the user's perspective (Tan et al., 2013). Therefore, to validate the requirements, this study examines the usefulness and applicability of an enjoyable deaf children's mobile learning application. Verification by the experts is important, and the main result is obtained to ensure the requirements are applicable. This was accomplished through expert reviews.

It is advised not to have fewer than three experts (Holzinger, 2005; Nielsen, 1994) participate in the verification process. Useful input was collected, and it is a very effective technique to gather reviews from experts for the verification process (Kontio et al., 2008; Martakis & Daneva, 2013). Besides that, this approach is one of the most convenient ways to collect data from experts (Dix et al., 2004). The experts refined the proposed requirements and judged their compliance with a set of matched requirements used to determine the accuracy of verification in the real world (Mohamed, 2015). Therefore, potential experts in the domain of UX, especially researchers and academicians, application developers, and disability experts, particularly hearing-impaired, were identified. The experts were chosen according to Hallowell and Gambatese's (2010) suggestion.

RESULTS AND DISCUSSION

The results are presented according to the three methods. The findings from each method are later combined and verified by experts.

Requirement Review

Based on the requirement review, as discussed in the previous section, the requirements for mobile learning applications for children who are deaf are synthesised and summarised in Table 3. Based on the table, eight researchers determined the requirements for deaf children's mobile learning. Some identified requirements have also been stated by other researchers, such as sign language, which has been mentioned by Nathan (2017) and Mutalib et al. (2016) in their studies. Based on Table 3, some requirements were produced after reviewing past research related to this study. The requirements are games (González-González et al., 2014; Marin et al., 2019; Ping et al., 2022), understandable (Basas & Pagliaro, 2014; Nathan et al., 2018), an interpreter of sign language (Nathan et al., 2018), and a simple design (Latiff et al., 2019).

Table 3

Summary of Requirements for Deaf Children's Mobile Learning from Past Research

Researchers	Requirements
González-González et al. (2014) Marin et al. (2019) Ping et al. (2022)	Games
Basas and Pagliaro (2014)	Easily understandable guideline Visual interface
Yeratziotis and Van Greunen (2013)	Visualisation, sign language
Mutalib et al. (2016)	Navigation, sign language, and flow of content
Nathan et al. (2018)	Interpreter, understandable, and simple design
Latiff et al. (2019)	Sign language, video tutorials, images, games

Fun Sorter

The following results are obtained from the second method of requirement gathering, FS. Each of the 13 children age from who are

deaf in a Malaysian deaf school received an FS form. They aged from 7 to 12 years old. The number of respondents is considered sufficient since the number of disabled participants in a study must be at least ten and more than 25 (Lazar et al., 2017). According to Table 4, the scores from the FS technique show that KoTBaM gained a total of 24 scores for the level of fun and a total of 33 scores for the easiest to do, followed by PopSignTest with 37 total scores for the level of fun and 28 total scores for the easiest to do, while ABIM indicated similar scores for the level of fun and the easiest to do, which are 17 total scores. Based on this result, it can be assumed that PopSignTest is the most fun and KoTBAM is the easiest mobile learning application to use, followed by PopSignTest and ABIM. Thus, the features from the applications with the highest rank are considered requirements for mobile learning for children who are deaf, followed by the other two (Read, 2008).

Table 4

Result from FS

Participant	KoTBAM		PopSignTest		ABIM	
	Level of fun	Easiest to do	Level of fun	Easiest to do	Level of fun	Easiest to do
1	2	3	3	1	1	2
2	2	3	3	2	1	1
3	2	3	3	2	1	1
4	3	2	2	3	1	1
5	1	2	3	3	2	1
6	2	3	3	2	1	1
7	2	3	3	2	1	1
8	3	2	2	3	1	1
9	2	3	3	2	1	1
10	2	1	3	3	1	2
11	1	3	3	1	2	2
12	1	2	3	3	2	1
13	1	3	3	1	2	2
Total Score	24	33	37	28	17	17

*Most fun

**Easiest to do

KoTBaM is a learning application developed based on the syllabus of communication sign language for deaf children in Malaysian deaf

schools (Maarof et al., 2016). Thus, the participants might feel that it is easy to understand the content of the KoTBaM since they have learned about it at school. Besides, some videos on constructing a sentence using sign language will give participants more attention to learning (Alias et al., 2016). Similarly, ABIM is also a learning application about sign language for communication, but only static images and simple animation show hand gestures. Meanwhile, PopSignTest is a mobile learning app with game elements like pop-up balloons. Users can interact with this application by translating the provided sign language into text and then popping it. It makes the user happy, especially children who like playing while learning and having fun with their lessons (González-González et al., 2014; Marin et al., 2019).

Based on personal communication between the authors and the teacher who conducted the FS data collection process, the participants appeared to prefer PopSignTest to KotBaM since it was a learning game application. However, as new words appeared, most began complaining that they did not have enough time to find the correct words. On the other hand, KotBaM has the content of deaf education that they learned at school. It makes the participants feel easy to understand and comfortable to learn, although they are not as excited when using PopSignTest. At the same time, ABIM is the least fun learning application rated by participants. As a result, fun and enjoyment elements should be prioritised in getting good experiences from this type of child since they are children who always like playing while learning (Marin et al., 2019). Thus, through the FS, it can be concluded that the requirements in KotBaM and PopSignTest are selected to contribute to an enjoyable mobile learning application for deaf children.

Interview

In addition to the FS and literature studies, interviews were also used to identify requirements for deaf children's mobile learning. The interview was conducted with four teachers at a deaf school and a mother of two deaf children. The four teachers have more than five years of teaching experience in special education studies. They taught subjects like Mathematics, *Pendidikan Islam* (Islamic Studies), *Bahasa Melayu,* and Computers. The Mathematics teacher taught pupils from Years 3 and 4 of primary school. The Islamic studies

teacher taught pupils from Years 1, 5, and 6. The *Bahasa Melayu* teacher taught pupils from Years 4 and 5. The Computer teacher taught pupils from Years 3 and 4.

The interviewees shared their experiences and difficulties as teachers and parents facing deaf children using mobile learning applications. Some requirements and needs have been detected through the discussion. It contributed to identifying the requirements for mobile learning applications for deaf children in depth. The interviews were analysed using qualitative data analysis software, which is widely used. Keywords such as "more images", "less text", "more video", "games", "guidance", and "alerts/ notifications" led to the discovery of deaf people having similar needs. Through the interview, perceivable item information, such as game elements, that are needed in a learning application was identified. Deaf children are more interested in learning applications that lead to their site. They prefer more graphics and videos than simple text (Nathan et al., 2018). It leads to the enjoyable usage of learning applications for them. According to the interview, participants agreed that deaf children need understandable content and simple tasks since they are relatively slow learners (Marschark & Spencer, 2016). As mentioned earlier, specific keywords known as nodes were found and grouped using qualitative data analysis software. It helps to determine the frequency of the keyword in expressing their needs for a deaf child's mobile learning application. Table 5 shows the nodes that have been identified as having significant deaf children's needs in a learning application through an interview. Comments from the participants are stated in short due to how people who are deaf or hard of hearing communicate with sign language.

Table 5

Nodes of the Requirements from Parents and Teacher Interview

Nodes	Parents' and Teachers' Comments
More video	Participants 1 & 2: "More videos."
	Participant 3: "More apps using video."
More images	Participant 1: "More images."
	Participant 3: "Images of sign language."
Less audio	Participant 3: "No need sound."

(continued)

Nodes	Parents' and Teachers' Comments
Games	Participant 1: "Have fun." Participant 4: "They are playful." "Play while learning." Participant 5: "Games element."
Easy to understand	Participant 1: "Easy to understand." "Graphic must be simple to understand." Participants 3 and 4: "Simple text." Participant 5: "Easy to learn."
Content	Participant 2: "Content from the textbook." Participants 2 and 4: "Interesting colour."
Simple to use	Participant 2: "Simple apps." Participant 3: "Easy to use." Participant 5: "Self-learning."
Difficult to be alerted on incoming information	Participant 4: "Vibration for any clicked button." Participant 5: "Flashlights or images of hand clapping may help in notifying them."

These nodes are essential requirements that must be included in developing a deaf learning application. Among the requirements extracted from the interview are more videos, more images, less audio, games, easy-to-understand, suitable content, simple-to-use applications and incoming alerts. Besides compiling the requirements of the deaf children from the interviews conducted, more precise literature, which supports similar requirements, was also gathered to support the requirement. The information was collected through a sectional literature review that identified similarities in the requirements mentioned. As shown in Table 3, there is literature discussing the requirements related to deaf children mobile's learning applications. The requirements are gathered through evaluation and observation during those studies. The information gathered from the literature, such as sign language interpreters, an understandable flow of content, and games, corresponds to the findings from the interviews conducted earlier. Table 1 states the features provided by the chosen learning application. Based on the FS results in Table 4, the features provided by KoTBaM are the easiest to do, followed by PopSignTest, which is the most enjoyable for deaf children. Hence, the requirements are derived from the features provided by the application. It has also been proven true by teachers and parents of deaf children through interviews conducted (Table 5). Table 6 shows the requirements gathered through an FS and interview that matches the literature studied.

Table 6

Matched Requirements

Requirement from FS	Requirement from Interview	Requirement Matched from Literature
Videos of sign language, images of sign language	More videos, more images	Visualisation, Sign Language,
Games	Games	Games
Easy to use	Easy to understand	Understandable
Simple task	Simple text	Simple design
User manual	Guidance	Interpreter

Table 6 shows that the FS, interview, and literature showed the importance of specific requirements to be instilled in mobile learning applications meant for deaf children. The requirements for a learning application with high FS scores are considered requirements for deaf children's enjoyable learning applications. It is because the deaf children themselves rank the scores. Only requirements that appear in all three techniques are reported in Table 6. Requirements with similar meanings have been matched, and the rest are combined since the words used have the same meaning. Any application, including the specific deaf mobile learning application, is commonly developed using universal design attributes that, reluctantly, do not comprise specific disability group requirements (Kraleva & Kralev, 2018). It also leads to the point that different users have different needs. Hence, the requirements for enjoyable learning and accessibility for deaf children are supported. It can also serve as a guide for developers in developing enjoyable mobile learning applications for deaf children.
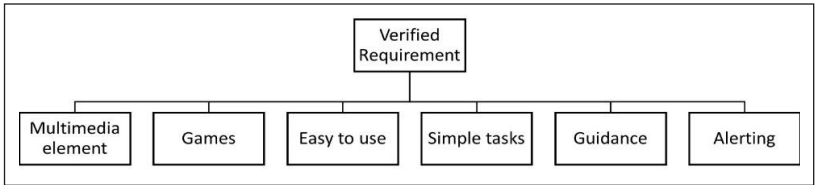
Requirement Verification

Through a focus group interview, the eight experts agreed to verify the requirement for an enjoyable mobile learning application for deaf children, as shown in Figure 4. For the requirement validation, a total of 8 (eight) agreed to validate the requirement. 37.5 percent of the experts are male, while 62.5 percent are female. All participants have experience in the UX domain, with 62.5 percent having more than three years of experience and the rest having one to three years of experience in the user experience and usability area.

The verified requirements are the combination of matched requirements from three sources to form a one-point word. The experts agreed to combine video, images, and visualisation as multimedia elements. Games are essential for an enjoyable learning application, especially for children. Easy to understand and understandable are considered together as easy to use since they agree that the application is easy to use if its understandability is good. As this study focuses on learning applications for deaf children, simple tasks are needed to avoid boredom until they are better equipped and ready to complete more difficult tasks. As mentioned earlier, deaf children are slower compared to normal children; thus, they need guidance to use a learning application. Finally, the experts also suggested alerting requirements for an enjoyable mobile learning application since it was highlighted for disabled children who need alerting to remind them.

Figure 4

Verified Requirements of Enjoyable Deaf Children's Mobile Learning Applications

Various requirements for creating an engaging mobile learning application for deaf children were identified through a review of previous research. These requirements include games, content that is easy to understand, the presence of a sign language interpreter, and a simple design. Specifically, the requirements from the KotBaM and PopSignTest applications were found to be essential elements for developing an enjoyable mobile learning app for deaf children. Additional requirements extracted from interviews highlighted that children who are deaf need mobile learning applications that have more videos and images, less audio, and suitable incoming alerts. These requirements serve as valuable guidelines for designing effective learning applications for this target audience.

The verified requirements represent a consolidation of matched criteria from three different sources into a single term. These criteria

include the integration of multimedia elements like video, images, and visualisation. Games elements and ease of use are crucial for creating an engaging learning application. Given the focus on deaf children, having simple tasks with alerts is essential to prevent boredom and accommodate their slower pace of learning and for those who require reminders.

CONCLUSION

As there are different types of deafness, there are also diverse user requirements. This study identified six basic requirements for enjoyable mobile learning applications for deaf children: multimedia elements, games, ease of use, simple tasks, guidance, and alerting. The requirements found are synthesised from deaf children's experiences as users, teachers, and parents of deaf children, as well as previous literature. Various techniques were used to obtain detailed requirements from various groups of participants. Thus, the result can be a guideline for designing a more enjoyable mobile learning application for deaf children. Through this guideline, improvements can be made to the new or existing mobile learning applications for children who are deaf, as these applications can be easily implied with the actual deaf children's requirements and better development of future mobile learning applications for this targeted group.

However, the requirements are limited for designing the mobile learning application for deaf children only. They are not directly applicable to other specific groups within the deaf community, such as those who are both deaf and mute or deaf individuals with additional disabilities. On the other hand, researchers may extend this study to investigate how these requirements work in designing a good learning application for children who are deaf. This study can also be extended by developing criteria for UX measurements based on these requirements to ensure positive experiences such as ease of use, enjoyment, and effective learning.

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APPENDIX

INTERVIEW SESSION (PARENTS)

BACKGROUND

Nama ibu/bapa/waris
Umur anak
Bilangan anak yang istimewa   /
Purata pendapatan sebulan
Tahap masalah pendengaran, apakah tahap hearing loss anak anda ?
(   ) moderate   (   ) severe   (   ) profound

INTERVIEW QUESTION

1) Apakah masalah paling nyata yang anda hadapi dalam menguruskan anak masalah pendengaran ini?
2) Berapa kerap anak anda tantrum jika kehendaknya tidak dituruti? Apakah tindakan yang anda ambil sekira ianya berlaku?
3) Adakah perbezaan tingkah laku antara anak-anak anda yang normal dengan yang istimewa ini? Jika ya, bolehkah anda terangkan secara ringkas berkenaan tingkah laku tersebut?
4) Adakah anda melibatkan diri atau anak anda dengan mana-mana pertubuhan atau komuniti masalah pendengaran? Mengapa?
5) Adakah anak anda mempunyai masalah lemah dalam pembelajaran jika dibandingkan dengan anak-anak yang lain?
6) Adakah anak anda mempunyai pengalaman menggunakan aplikasi telefon, courseware atau web untuk kanak-kanak masalah pendengaran? Jika Ya,
   i.   Bolehkah anda terangkan secara ringkas berkenaan aplikasi tersebut?
   ii. Apakah ciri-ciri yang paling anda suka tentang aplikasi tersebut?
   iii. Apakah benda yang menyebabkan anda frust tentang aplikasi tersebut?
7) Adakah anak anda menggunakan sebarang teknologi interaktif semasa belajar sendiri di rumah?
8) Jika ya, apakah masalah yang anak anda hadapi semasa belajar sendiri? Jika tidak, mengapa anda memilih untuk anak anda tidak menggunakan teknologi interaktif untuk belajar di rumah?
9) Bagaimana penerimaan anak anda terhadap teknologi dalam pembelajaran? Adakah mereka boleh mengikuti perkembangan teknologi atau takut untuk mencuba sesuatu yang baru?
10) Pada pendapat anda, sekiranya anak anda ini diperkenalkan dengan aplikasi telefon, adakah mereka boleh belajar sendiri melalui aplikasi tersebut tanpa pemantauan daripada anda?
11) Apakah yang anda impikan daripada sebuah aplikasi telefon pembelajaran untuk anak anda yang masalah pendengaran ini?
12) Berikan sebarang cadangan untuk menjadikan aplikasi tersebut menarik untuk digunakan oleh kanak-kanak masalah pendengaran ini.

INTERVIEW SESSION (TEACHERS)

INTERVIEWEE BACKGROUND

Nama
No. K/P:
Pengalaman Mengajar
Pengalaman mengajar murid masalah
pendengaran (tahun)

INTERVIEW QUESTION

1) *Apakah matapelajaran yang diajar di SKPK?*
2) *Adakah anda mempunyai pengalaman menggunakan aplikasi telefon, courseware atau web untuk kanak-kanak masalah pendengaran? Jika Ya,*
    a. *Bolehkah anda terangkan secara ringkas berkenaan aplikasi tersebut?*
    b. *Apakah ciri-ciri yang paling anda suka tentang aplikasi tersebut?*
    c. *Apakah benda yang menyebabkan anda frust tentang aplikasi tersebut?*
3) *Adakah anda menggunakan sebarang teknologi interaktif semasa proses pembelajaran di dalam kelas? Ya / Tidak*
4) *Jika ya, apakah masalah yang anda hadapi semasa mengajar dalam kelas? Jika tidak, mengapa anda memilih untuk tidak menggunakan teknologi interaktif dalam pengajaran dan pembelajaran?*
5) *Bagaimana penerimaan murid-murid ini terhadap teknologi dalam pembelajaran? Adakah mereka boleh mengikuti perkembangan teknologi atau takut untuk mencuba sesuatu yang baru?*
6) *Pada pendapat anda, sekiranya murid-murid ini diperkenalkan dengan aplikasi telefon, adakah mereka boleh belajar sendiri melalui aplikasi tersebut tanpa pemantauan?*
7) *Apakah yang anda impikan daripada sebuah aplikasi telefon pembelajaran untuk murid-murid masalah pendengaran ini?*
8) *Berikan sebarang cadangan untuk menjadikan aplikasi tersebut menarik untuk digunakan oleh kanak-kanak masalah pendengaran ini.*