Investigation Towards the Needs of Affective Design Principles of Mathematics Mobile Application for Low Vision Learners

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Abstract

The aim of the study is to investigate the development of affective design principle of mathematics mobile application needs for low vision learners. Semi-structured interviews have been performed for the investigation as a method. As a result, the needs for affective design principles of mobile application in learning mathematics for low vision learners have been confirmed. In conclusion, it is clearly revealed that the existing mobile application specifically design for affective design principles is still scarce and there is a significant needs towards the development of affective design principle of mathematics mobile application for low vision learners.

KEYWORDS: assistive technology; human- computer interaction; mobile application; affective design; low vision

INTRODUCTION

The increasing use of innovative Human-Computer Interactive (HCI) devices (e.g., computers, smartphones, wearable smart technologies) have sparked a new demand in which users of such technologies appear to be increasingly able to exchange psychological and cognitive states with mobile and online monitoring and archiving systems [1]. Additionally, some researchers also believe that if an electronic device can recognise and physiologically express an emotion, it will be possible to elicit emotional responses from users [2]. Thus, many studies have investigated the significance of a user's emotional state in education especially such as the adaption of educational virtual environments [3], the development of emotion recognition robots to aid children with special needs in the classroom [4]) and the detection of a student's frustration educational game-based learning [5] are all examples of recent developments. Whereby, in computer science area, researchers look at the implications of a user's emotional state when using software in order to improve the user's experience [6].

Therefore, [7] coined the term "Affective Computing," which refers to techniques that allow computational systems to perceive and respond to human emotions through

the use of computer interfaces. Furthermore, affective design is the process of creating a product with the goal of encouraging people to have specific emotional experiences and reactions., such as happiness, pleasure, trust and confidence [8]. Previously, the use of affective elements in multimedia learning was discouraged because affective features were viewed as a source of superfluous cognitive load [9]. However, recent research [10] suggests that the use of affective elements in multimedia in learning may be beneficial in providing motivational as it can improve learning.

In order to provide affective learning, appropriate design principles for mobile learning application should be extended in effective way. The needs of affective design principles that promotes students' motivation and mediate student to have better understanding of concepts in Mathematics subjects through affective design principles implemented in mobile application have motivated this study. Thus, this study has made use of affective design principles been implemented in the assistive technology (AT) to help the low vision (LV) learners as well as for assisting special needs teacher so the quality of special education in Malaysia can be enhanced.

Whereas mathematics act as a core subject that is vital and closely related to daily life. Students need to understand the concept very well and practise them in their learning and real life [11, 12] added that mathematics is compulsory for our daily lives, despite of educational background or social status. In addition, the benefits of taking mathematics into account is not limited to knowledge in basis calculation, however it gives a huge contribution to one's thinking skills to be more rational and critical [13]. Furthermore, mathematics subject incorporates of conceptual and practical understanding [14]. Thus, mathematics become more challenging for the LV learners as it encourages critical thinking in problem- solving. Critical thinking needs to be integrated and emphasized in learning Mathematics [15]. However, mathematics is very difficult to learn by visually impaired (VI) children [13]. Mathematics are usually represented as a visual material which affects their performance of arithmetic operations that exist as a symbol in mathematics subject[13]. Therefore, teaching strategies and aids is a crucial component of to achieve a positive learning environment [16]. Choosing suitable teaching methods will contribute to a greater understanding of mathematics among students especially for LV leaners.

However, due to the world current situation of pandemic covid-19, which is highly affected the education institutions, digital learning can be a preferable potential alternative. Mobile learning or m- learning offers the measures of benefits of multimedia or mobile learning. Teachers need to be equipped with the technology approach. Therefore, they should equip themselves with relevant technology skills and approach to ensure their teaching is effective.

For the purpose of this study, a investigation on the needs affective design principle in the development of mobile application that specifically designed for primary schools of LV learners has been conducted. Mobile application aims to aid the LV learners in learning Mathematics subject. Since the advancement of technology in AT is demanding especially for educational purposes, there is a need to identify the relevant affective design principles of accessible mobile application for visual disabilities. Hence the affective design principles in mobile application referred to the use of AT in increasing the accessibilities for LV learners in learning Mathematics. However, the existing software development seems not deploying to the need of special people [17]. Hence, affective design principles need to be developed in order to reach out many LV learners.

Since the affective design principles and their benefits are relevant for LV learners to apply in solving the mathematics problem in their studies, this study has applied them in the mobile application. Through the mobile application, it is hoped that the LV learners will be able to understand the concepts and helps them in the problem solving.

LITERATURE REVIEW

Affective Design in Mobile Learning

Affective design is an attempt to determine the emotional links that exist between consumers and products, as well as to study the perceptual design components that are associated with the affective characteristics of the products [18]. A more recent example is the affective design implemented in mobile health application that is intended to be emotionally engaging to the rural community setting in South Africa [19]. The application has adopted the affective design such as interactive agents developed from community legend.

As a result, the mobile health application elicits the emotional response from the user and trigger the user to frequently to login into the application for updating their medical report, appointment setting, and obtaining health information. Therefore, this is best to argue that the relevance of affective design can be expressed as a mobile application with good affective design will elicit psychological feelings in the user and increase the user's pleasure in terms of emotional elements.

In another study by [20] on Effects of Interface Design Factors on Affective Responses and Quality Evaluations in Mobile Applications stated interface design of an application can convey a perception of quality from individual's daily task perspective or increasing the individual's competency. As a result, this will improve the user's pleasure in the engagement with the mobile application. Hence, in this study, researcher aims to increase the emotional experience of low vision learner in learning mathematics subject despite of their limited eyesight by adopting affective design in the mobile application. This will increase the learning competency of low vision learners in mathematics subject through mobile learning.

On the other hand, according to Fisk in his article Education 4.0: The Future of Learning (2017), there are nine trends related to Education 4.0 where the need of diverse time and place for learning to occur has been highlighted as the first trend for Education 4.0. This trend is related to the emergence of education and technology that lead to e-learning tools that offer great opportunities for remote, self- pace learning that can be taken place anytime and anywhere [21]. E-learning is computer aided learning whereas mobile learning (m-learning) is a one type of e-learning, where teaching and learning process is conducted by the means of internet, computer, visual and audio devices. However, mobile learning is perceived to has various definitions such as m-learning, u- learning, learning while mobile, personalized learning, anytime or anywhere learning and handheld learning [22]. Furthermore, mobile learning potentially support teaching and learning in 21st century by the implementation of digital technology in education. Mobile learning also enhances the learning ability among the students [23]. Hence, this study is motivated in adopting affective design in mobile learning for LV learners in learning mathematics.

Mathematics Mobile Learning

In the last decade, there have been significant shifts in the capabilities of technological innovation. As a result of the increasing prevalence of smart mobile devices, a growing number of people are beginning to believe that a new type of educational software could be an appealing way to deliver instruction to youngsters, provided that the software is well-designed and appropriate for the children's age. Technological abilities appear to emerge in children as early as infancy, with the majority of this learning occurring inside the family environment through observation and imitation of their family members' digital behaviours. Children's education, in the opinion of their parents, is made more difficult until they understand digital technologies and develop digital abilities. As a result, they feel that schools must play an important role in providing digital literacy instruction to students in the lower age groups.

When technology is used to aid in the development of children, it is most effective when it is tailored to their needs, age, needs, interests, and socio-cultural context.

Nowadays, young children are immersed in a digital culture that includes the use of advance gadgets such as electronic tablets, electronic readers, and smartphones, which enable them to discover and engage with a number of applications as well as different types of print and digital text. Some studies have analysed the effectiveness advanced interactive technologies, such as tablets and other smart handheld mobile devices, which have the potential to provide significantly more learning possibilities [24] than are now available on traditional platforms [25]For instance, the findings of [26], who determined that tablets are the most popular type of device preferred by the young children for viewing online movies, playing interactive games, drawing, listening to music, and conducting informational searches. For parents of young children, this gadget has a number of major advantages, including a touchscreen display, mobility, and the advanced usability of touchscreen technology [26]Because of this, it is frequently used in societies that see it as a "family" device or a valuable asset for children and young people [26]

Consequently, children will have access to educational applications and designs that are age-appropriate for their development, as well as the ability to design, create, and publicly express their thoughts [27]. While there has long been debate and controversy about the introduction of technology in the context of early childhood education, there is now widespread agreement that young children must have some access to software in order to become familiar with a wide range of software programmes and to learn how to use them [12]. Schools may play an essential role in the development of digital competences, which can be heightened even further by incorporating digital technology into the classroom as active learning tools. Numerous important factors influence the adoption of digital technological gadgets as instructional tools in early childhood education, all of which are discussed in detail below. According to[28], the most important element determining the future use of new interactive technology in the learning process is prior experience with this sort of technology.

The adoption of smart mobile technology is mostly motivated by the children's belief that it is simple to use and that it provides them with significant benefits in early childhood education [28]. To put it another way, children who have demonstrated exceptional aptitude for using modern mobile devices have learned to appreciate the educational benefits of these emerging technologies, as seen by their ability to recognise the benefits in their respective areas of science study [28]. The use of digital technology in instructional purposes may also have a beneficial effect on parents' positive attitudes of the usefulness of digital technology as a learning tool, and it may encourage parents to advocate for their children's digital education[26].

This study is primarily concerned with the needs of affective learning approach of mathematics by the means mobile devices that are associated with the needs of LV learners. The ultimate goal is to provide a better understanding of the influence of assistive mobile technologies on LV learners learning procedures as well as the potential of mobile application in assistive technology.

Existing Mobile Application

Referring to Table 1, there are quite a few existing mobile applications for low vision and blind person available from recent studies, however, there are none of the mobile application that really incorporates the usage of affective design principles as envisioned in this study. Furthermore, there are still confronting of some accessibility issues in the mobile application which have been highlighted as the main issues derive from the limitation and discussion sections of each study. The deficiency in most of these applications are the size of text utilize in the applications that led to user’s confusion, disturbance of interaction with the mobile application. Hence, this will affect

the effectiveness of the mobile application to cater with the needs of LV learners due to their limitation of eyesight.

Table 1

Table of Existing Mobile Application

No	Mobile Application	Limitation	Discussion
1.	All Appointments [29]	Accessibility	1. Layout structure 2. Colour contrast
2.	Sejahtera [30]	Accessibility	1. Small size of text 2. Delay in voice recognition
3.	Tourism for All [31]	Accessibility	1. Small size of button
4.	mySugr [32]	Accessibility	1. Not aware of functional button 2. Nonsensical text read by screen reader
5.	FarmaceuticApp [33]	Accessibility	1. Small size of text
6.	Serious Game [34]	Accessibility	1. Small size of text
7.	WordMelodies [35]	Accessibility	1. Text clarity
8.	MagVi [36]	Accessibility	1. Lost in navigation 2.Low colour contrast
9.	MusA [37]	Accessibility	1. Problems with audio playback
			2. Feedback not clear as insufficient color contrast 3. Small touch area
10	Kai Access [38]	Accessibility	1. Small size of text

In accordance, a investigation has been conducted to investigate the needs of affective mobile application specifically design for the needs of LV learners.

METHODOLOGY

The investigation has been conducted through interviews in identifying the needs of mobile application for LV learners. The first interview with the subject domain experts in education setting to identify the context of knowledge and the needs of mobile application in teaching and learning LV learners. While the second interview conducted involving expert in low vision to identify the background of LV learners by confirming the LV background and health condition. The compilation of the interviews of subject domain experts in education and low vision will be discussed in the next subsection. The analyses of these interviews further strengthen the findings of this study.

RESULT AND DISCUSSION

Interview with Mathematics Education Teacher

The objectives of the interviews are (i) to gather the information regarding the availability of mobile application for low vision learners, and (ii) to clarify the factors that lead to the needs of mobile application for low vision learners. Therefore, a series of interviews were conducted by involving two respondents, who are the subject domain experts. They are mathematics teacher at different special needs school namely as R1 and R2 respectively. The sessions between this study and subject domain experts were done one by one at different time and place. In the interview, 12 questions as listed in Table 2 were asked in a semi-structured format.

Table 2

Semi- structured Interview with Mathematics Education Teacher

Scopes	Questions
Learning material	Q1: Are the low vision learners exposed to the digital learning material?
	Q2: Are the low vision learners exposed to the utilization of mobile device?
	Q3: Are the low vision learners are exposed to the mobile applications specifically designed for LV learners?
	Q4: Does the usually used digital platform (application/ courseware) contain audio, graphics, animation, and video?
	Q5: Does the digital platform (application/ courseware) have the features to assist the low vision learners during the learning process?
Availability of mobile application	Q6: Is there any standardized mobile applications designed for low vision learner provided by MOE for special needs school?
	Q7: Are the mobile applications available in the market suitable for low vision learners?
Needs of mobile application	Q8: Do you recommend for a proper mobile application that is specifically designed for low vision learners?
Subject requirement	Q9: What is the most critical topic in teaching Mathematics?
	Q10: Why that particular topic considered as difficult topic among students?
	Q11: How is the usual teaching method for that particular subject?
	Q12: What is the need of that particular topic to be in a digital form/ application?

Learning Material

The teachers in the study knew that multimedia approach is the most effective learning material in teaching Mathematics. Based on Q1, R1 uses the courseware available in the computer at the school's laboratory to aid their learning for a better understanding of the concept. However, the teacher said they rarely use the hand-held device such as tablet as there is no specific application for the LV learners to explore. So, the teacher tends to utilize the already installed courseware named Math Flash (refer Figure 1.1) in the computers. According to the teacher, learning only by the textbook will make the LV learners harder to understand due to the size of the fonts are too small and lack of interactive elements to attract them to understand. Contrary to R2, the school never had the courseware as per R1. However, R2 still uses digital learning materials such as Youtube or website as for the digital learning material. The

students need to adapt with the general educational videos and websites in learning Mathematics.

Based on Q2 and Q3, both R1 and R2 stated that they utilize the mobile device such as tablet during the lesson, but most of the applications are limited for general students only. There are no other choices instead of to open the application using tablet and enlarge or brighten the screen display.

Based on Q4 and Q5, R1 refers to the courseware where the courseware is too basic (refer Figure 1). The courseware does not contain any multimedia elements of audio, graphics, animation, and video. The students need the teacher to aid them to operate the courseware. However, R2 refers to the most frequent applications they use which is Youtube which apparently contains all the multimedia elements, however the elements are not suitable for LV learners.

Availability of mobile application

R1 responded to Q6 as the available courseware installed in the school's laboratory is from unidentified source and was analysed by the researcher based on other special needs schools, there is no courseware as mentioned. There is no standardized courseware or applications from Ministry of Education to the special need schools in Malaysia. R2 has confirmed their school also does not have the courseware as well.

Hence, it was found out that all the learning materials used are the same with the general students including textbooks as there is no standardization from the Ministry of Education in the development of mathematics model for LV learners. R2 added there also not enough assistive aid that been supply to the school. The assistive aids supply also are very limited and only selected special needs school will receive well- equipped assistive technology. In addition, if the assistive aid broken the will be no replacement and their student need to adapt their learning without them. For example, the CCTV for enlargement of the text is broken the student will have to adapt without it. Sometimes thy will borrow from the other school.

R1 and R2 both responded to Q7 that almost all of the available applications are not catering to the needs of LV learners in learning Mathematics. They are not familiar with other applications available in the market as mostly for general students. Even though sometimes they use such as educational videos in Youtube for learning, the LV learners need to adapt with the content provided as most of them are designed for general students.

Needs of mobile application

R1 stated that the motivation level when the LV interact with the courseware, or any mobile application is different with the conventional teaching in the class. They are performing better when learn using the courseware. R2 stated that when using Youtube as learning material for the student they need to repeat the video multiple times for the student to understand the concept.

However, learning through the means of multimedia is the best choice in making the student more understandable with the mathematical concepts. Therefore, both R1 and R2 highly suggested and delighted in recommending a proper mobile application that specifically designed for LV learners as for their response for Q8.

Subject Requirement

R1 responded to Q9 as the most critical subject is multiplication and division which requires the LV learners to visualize the object to perform the calculation, whereas the available courseware only acts as enlarged digits in the digital form of

courseware. R2 responded to Q9 with the same subject and added fraction also having the same difficulty for the LV learners to understand.

According to R1 based on Q10 multiplication and division requires LV learners to look at the object or visualizing the objects to perform calculation. They need to have an attractive visual to ease them to perform calculation based on grouping the objects. R2 responded as LV learners are having problems with the same topic as well. R2 stated that even though they have played the educational videos on that particular topic the LV learners need to take some time in order to adapt with the learning content and understanding the content itself.

Both of R1 and R2 will opt for a concrete learning material or hands-on learning material such as cups, paper plates to explain the concept more clearly. The digital learning provides limited understanding of the concept as poor instructional contents and elements are implemented in the applications.

R1 responded to the Q12 as there is a need to incorporates with a new mobile application that implemented all the specific design to evoke positive reactions for the LV learners in learning Mathematics. R2 responded to the Q12 as the textbook separated the topic by topic however the operational is still the same. For example, multiplication in time is same as multiplication in money. However, the topic is separated in the textbook. It is hoped that in a mobile application with the usage of multimedia elements such as using multiple types of graphics such as clock and money notes in one place can elicit the understanding of LV learners in performing the multiplication and division operation.

In this study shows that there is an urge on the needs of assistive mobile application for LV learners in learning Mathematics. In addition, the total of visual impairments poses an increasing trend based on the statistics from 2016 to 2020 shows a big challenge from day-to-day learning activities for the LV learners. These results clearly indicate that there is a lack in the development of assistive mobile application for LV learners and the needs of the AT development.

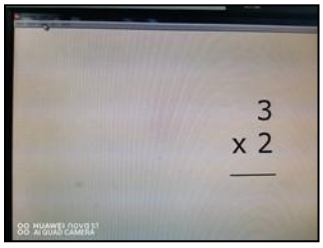

Figure 1 Math Flash Courseware

Interview with Low Vision Expert

Studies on mobile application need to be accelerated to comprehend the needs and requirements of low vision users. Therefore, it is important to analyse low vision learners' background, health condition, and interaction LV towards AT in relation to learning through mobile application. A series of semi- structured interview have been carried out with the expert in low vision about the low vision background and the assistive technology used for the low vision. The respondent has been addressed as R3. The low vision expert is a vision rehabilitation optometrist who has an experience managing LV communities in United Kingdom and currently a lecturer in one of universities in Malaysia. In the interview, 6 questions as listed in Table 3 were asked in a semi-structured format.

Table 3

Semi- structured Interview with Expert in Low Vision

Scopes	Questions
Low Vision Background	Q1: What is the definition of low vision?
Health Condition	Q2: What is the specific term for type of low vision which has the blurry vision despite of the one who has specific range of sight such as tunnel vision (called glaucoma)?
Interaction with the Assistive Technology	Q3: Based on your experience in managing LV community in UK, how is the AT applied there?
	Q4: Does tablet/ mobile application compatible with LV learners?
	Q5: Between visual and audio, which is more atracted to the LV?
Future Perceptions	Q6: What can you say about the future of LV learners? What can guarantee the brighter future of this community in Malaysia setting?

Background of Low Vision

R3 respond to Q1 by stating the general definition of low vision from World Health Organisation. Then R3 further narrowing the definition based on Malaysia setting. Low vision is a condition where an individual has visual acuity is less than 6/18 up to 3/60 or when the visual field is less than 20 degrees in the better eye despite the best possible corrections.

However, R3 stated that based on the definition, there is a 'thing' left in the definition which is the term of 'functional low vision'. R3 stated despite of having a low vision, if the patient has the ability to do their daily activities for example cooking, walking. The patient considered has the potential with the rehabilitation or intervention. For example, interacting with the application devices or magnifying glass (e.g assistive devices).

[39] mention in his book Assessment of Low Vision in Developing Countries that functional vison refers to the use of small amount of useful vision for a particular purpose such as to recognise a person close up, or to avoid objects.

Health Condition

R3 responded to the Q2 as it is plausible to choose the condition of 'Overall blurry' as target user as it is the most common diseases occurred to LV especially for children. R3 coined the term 'Overall blurry of vision' which all of the types of low vision can cause overall blury.

Interaction with the Assistive Technology

R3 answered the Q3 by comparing the Malaysia setting with the UK setting of LV community. Both countries have the same schools that is provided specifically for visually impaired students. However, in terms of technology of course the technology in UK is more advance according to the high charge of tax and awareness about the technology for visually impaired.

R3 respond to Q4 based on the technology engaged with the rehabilitation for LV. R3 stated it is the best to use tablet as medium for learning in term of its portability. While R3 stated the answer for Q5 that is best to combine both elements low vision visual as people with low vision usually can hear better. So, it best to combine both elements.

Future Perceptions

R3 respond to the Q6 by stating that the future for people with LV is bright if they try to engage and explore more with the use of technology despite of using the normal devices such as magnifying glass. In addition, there is a need to improve the teachers' skills in teaching and learning for LV learners by using technology in the classroom.

This study has clearly shown that the needs of the affective design principle development of mathematics mobile application for low vision learners is relevant. There is clear evidence that the needs of mobile application for low vision learners is highly demanded. To clarify all the discussed facts, Table 4 summarize all the investigation findings based on the target user's background, learning materials that are currently used in teaching and learning of LV learners, availability of mobile application, the needs of mobile application and the subject requirement.

Table 4

Investigation findings

Scopes	Questions
Low Vision as a target User	- Lack of technology used in education setting for LV learners - Limited interaction with mobile application for learning purpose due to eyesight problem.
Learning Material	- Using the general digital learning material such as Youtube. - Limited expose to the specific application for LV - Engage with all the multimedia elements with limited control over the learning material.
Availability of mobile application	- Unstandardised of courseware supply for different special needs school. - Limited market availability of mobile application for LV.
Needs of mobile application	- Existing application too general. - Too boring conventional method of teaching. LV learners more motivated in technology used in teaching and learning. - Shows positive reaction towards the use on courseware or mobile application despite of conventional teaching in class.
Subject requirement	- Most of the topics are critical such as basic operation that involve multiplication and division. - Mathematics require more visual- attention as it involves symbols. - Uses conventional teaching method with hands- on material to visualize the concept.

Table 4 has indicated that the need for educational mobile application for low vision learners is high and it is urgently necessary to motivate the user as mentioned also by [28] in learning mathematics despite of their limited eyesight.

CONCLUSION

This investigation is indeed important as the early intervention in developing a more accessible affective mobile application for LV learners. It would be the basis in the design and development of assistive mobile application to assist the LV learners in learning mathematics subject through affective design principles and as a result, LV learners will enhance their emotion and interest in learning mathematics. Based on the investigations that has been conducted, it is clearly revealed that the needs of mobile application for learning mathematics is highly needed to assist both teachers and LV learners through teaching and learning mathematics. Therefore, there is a necessity

to propose the affective design principles of mobile application for LV learners in overcoming the accessibility issues from the existing mobile application.

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