Malaysian Journal of Educational Technology
Volume 9, Number 2, December 2009

Learning Science Using AR-Book by Blended Learning Strategies: A Case Study on Preferred Visual Needs of Deaf Students

Norziha Megat Mohd Zainuddin, Halimah Hj Badioze Zaman & Azlina Ahmad
College Science and Technology, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, MALAYSIA
Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, MALAYSIA

Abstract

Augmented Reality Book is known as AR-Book which one of application of Augmented Reality (AR). AR is the current technology which is based on visually oriented technique, especially with those related to abstract concept in learning Science, that can be used in teaching and learning for the deaf. In this ongoing research, qualitative approaches were used. The techniques chosen were observation and interaction with the deaf students. Meanwhile, interviews with teachers and officers who were related to the education of deaf students were also conducted. Observations from three deaf students were chosen to investigate the visual learning criteria of science skill process that involved identifying and communicating. From the finding through the observation and interaction with the deaf students, the researcher had acquired that the deaf students share some similar learning behaviors, among them in learning science. This prompted the researcher to design and develop an AR book called AR -Science in Deaf (AR-SiD). This AR-book is a blended learning approach, which is aimed to increase the understanding of deaf students in learning science, particularly in Microorganisms topic.

Zainuddin, N.M.M., Badioze Zaman, H. & Ahmad, A. (2009). Learning Science Using AR-Book by Blended Learning Strategies: A Case Study on Preferred Visual Needs of Deaf Students. *Malaysian Journal of Educational Technology, 9*(2), pp. 5-20.

Introduction

Augmented reality is also known as AR is a type of virtual reality in which is designed to combine virtual representations with perception of the physical world. It also gives users additional information about the physical world which is not perceived by unaided human senses (Billinghurst, 2002; Sherman & Craig, 2003). As shown in Figure 1 a reality-virtuality continuum was proposed by Milgram et al. (Milgram & Kishino, 1994) describe a taxonomy that identifies how augmented reality and virtual reality are related. The taxonomy also shows that computer interfaces can be placed on a continuum according to how much of the user's world is generated by the computer. The continuum show that the real environment on one end, and the virtual environment on the other. In between them are flavors of integration, augmented reality (AR) and augmented virtuality (AV), depending on whether reality or virtuality is being enhanced. Besides that, mix reality (MR) technology can be used to shift users smoothly along the continuum.

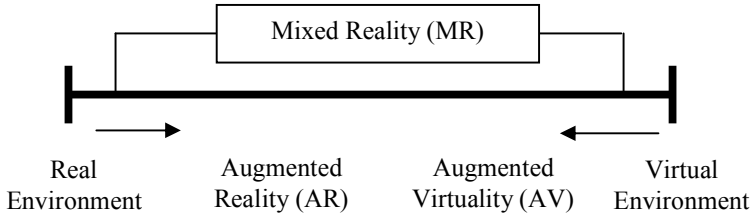


Figure 1 Reality-Virtuality Continuum (Milgram & Kishino,1994)

In recent years, there have been many developments with regards to AR. AR has extremely wide applications across a whole range of disciplines. It has been applied in many fields, like videoconferencing (Barakonyi et al, 2003), entertainment (Barakonyi & Schmalstieg, 2005), training and education (Hughes et al, 2005) and others. One of AR applications is known as Augmented Reality Book or AR-Book. Augmented reality and blended learning are the characteristics of neo-millennial learning style which can motivate students through learning (Lui et al, 2007b; Sankey, 2006). Neo in this context meaning new meanwhile, millennial refers to the learning modality required for the new millennium (Sankey, 2005).

The concept of AR-Book was proposed in Magic Book project (Billinghurst et al, 2001). Previous researches showed that there were a few advantages using AR book in education. By using AR book, users can get better visual quality of reading (Grasset et al, 2007; Grasset et al, 2008a, 2008b). Besides that, users still love the physicality of real books which offer a broad range of advantages such as portability, flexibility, robustness, etc (Marshall, 2005). In addition, AR book can also be a good learning medium to support low ability reader (Dunser, 2008; Hornecker & Dunser, 2007) and it can be implemented in classroom environment (E.Shelton, 2002; Lui et al, 2007b). This is because it can be in accordance with the teaching syllabus, suitable for the classroom environment and at the same time, motivate students, and made suitable for self-learning and robustness for the personal users by using markers. Therefore, by using AR book, there is a potential to make learning and teaching more interesting and meaningful by making learners' experiences more engaging. In addition, students can capture knowledge faster and have deeper impression of subject learned.

The main purpose of this study was to design and develop Augmented Reality Book for the deaf in Science, Microorganisms topic by using blended learning strategies. This AR-Book is called Augmented Reality Book Science in Deaf (AR-SiD) which includes online learning that can interact with the AR-Book. Besides that, in online learning, the deaf students can print worksheets for doing exercises.

The objectives of this preliminary analysis are:

- To identify learning behavior faced of the deaf students' visual literacy in Science subject year five.
- To determine whether the deaf students can visualize words corresponding to the pictures given by the researcher.
- To identify the visual communication which includes sign language, finger spelling and written text of deaf students' correspondent to the pictures given.
- To analyze in percentage the level of favoritism of pictures given either in sketch, 2-Dimensional (2D) or real pictures that deaf students like most.
- To identify the reason given by the deaf students in choosing the pictures.

The remaining article is structured as follows: First, the background of problem faced by the deaf students in learning. Next, the literature review related to this topic followed by the methodology used such as interviews and observation techniques. The findings of the study were discussed and summarized. The article concludes with the blended learning strategies by using AR Book in Science called AR-SiD for deaf learners.

Background of Problem

It is common that the main problem with the deaf children is communication. They are often delayed in language development compared to their hearing peers (Kyle & Harris, 2006; Mayer, 2007). Besides having problem in communication, deaf students also have problems in visual literacy in Science subject, especially in visualizing the abstract words (Norziha Megat Zainuddin & Halimah Badioze Zaman, 2009; Passig & Eden, 2000).

From the interviews that have been done, teachers said that being visual learners, deaf students have problems with current text books, which are more text-based than graphic based. Teachers said that, there are no special books or courseware developed for the deaf students in learning science. Teachers are using current technology such as multimedia courseware in CD-ROM which is supplied by the Curriculum Development Centre but it is not suitable for deaf students, because it was all developed for the normal learners.

Due to these problems, the deaf students have included significant delays in language development and as a result they are having problem in academic achievement (Abdullah Yusoff & Che Rabiaah Mohamed, 2002; Yoshinaga-Itano et al, 2006). Besides that, these students also face science visual literacy problems and they are not making great accomplishment in science process. This is illustrated in Table 1 below where it shows the result of *Ujian Pencapaian Sekolah Rendah* (UPSR) science subject for the deaf student in 2007 and 2008. Result shows that the number of students who failed (82.38%) is greater that the number who passed which is less than 17.63% in 2007. The same situation happens in 2008, which the number of deaf students who failed is greater (84.77%) compared to those who passed (15.21%) (Jabatan Pendidikan Khas, 2007).

Table 1 UPSR result for the deaf in year 2007 and 2008 in Science (Special Education Department , 2008)

Year	Gred	2007		2008	
		Frequency	%	Frequency	%
Pass	A	2	0.72	0	0
	B	9	3.24	0	0
	C	38	13.67	14	15.21
Fail	D	41	14.75	24	26.08
	E	188	67.53	54	58.69
Total Candidate		278	100	92	100

Nowadays, the trend of educational environment is changed by using the neomillennial learning approach. The neo-milleannial approach like Augmented Reality (Dede, 2005; Lui, Cheok et al, 2006) and blended learning (Sankey, 2006) can be combined together to make the learning become more meaningful. However, technology advancement and the greater use of multimedia such as AR in education have provided an opportunity for course leaders and designers to enrich students' learning experiences by providing technology-based learning resources that comprise a range of multimedia and on line component. Thus, looking at these characteristics of neo-millennial learning style, they are found suitable to be applied by the deaf students (Lui et al, 2007a).

Literature Review

Blended Learning

Blended learning is a type of neo-millennial learning style (Dede, 2005), known as hybrid learning or mixed mode courses (Young, 2002). Blended learning is a combination of coursework in a traditional classroom setting with an online component. In the online component, students can work independently in a virtual environment (eLearners.com, 2007; Sankey & Hill, 2005). The characteristics of blended learning are (eLearners.com, 2007) as below;

- It can be carried out as workshops, symposiums, labs, or even in some class meeting.
- It is very suitable for those courses that involved structured exercises.
- It is particularly convenient for those students who live several hours from campus, or those who have transportation problem, or those who have physical disability.
- It is able to enhance students' learning hours at home.

Research shows that in Bloomsburg University of Pennsylvania, they have already used blended learning for the learners who are deaf, hard of hearing and hearing. Students attended the formal classroom integral parts in the online course. Here, they were provided a "virtual classroom" with a common meeting time. Audio and video components were used in that course. The key element of online course provides the effective communication and interaction (Slike et al, 2008).

Other study investigated how blended learning has influenced six grades with different cognitive ability in an elementary school in Taiwan. It showed that with different teaching approaches, students with lower learning capabilities had shown a remarkable difference in the post-test in environment education (Chen & Huang, 2009).

Another research that was done by Faaizah (2008), which was a multimedia software teaching science, on Nutrition topic based on a hybrid Problem Based Learning approach called C^2HADAM. This research was conducted in a secondary school in Shan Alam, Selangor. It was participated by 64 form two students. This multimedia courseware contained web base course and printing worksheet. The finding showed that using C^2HADAM courseware was more effective approach as compared to the conventional approach (Faaizah bt Shahbodin, 2008). Based on the previous studies conducted, this study attempted to apply blended learning among the deaf students in primary school especially in Science
subject by adopting augmented reality book for them.

Scientific Acquisition in Science Process

Scientific acquisition is important in doing activities which are based on science principles (Hiang, 2001). The scientific acquisition is divided into two, acquisition in science process and manipulative acquisition. The acquisition in science process is also divided in two parts; they are the basics and the integrated. This can be seen in Figure 2 below.

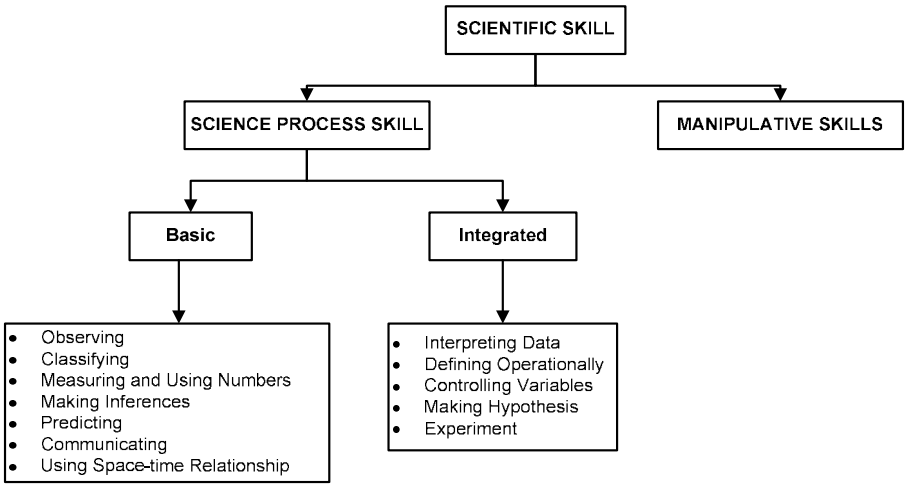


Figure 2 Development for scientific acquisition in Science Curriculum (Hiang, 2001)

The basic acquisition process in science is divided into five fields of study. There are universal life, physical life, material life, earth and universe, and lastly technological world. Microorganism topic falls under the universe life category. In that topic, the science process skills involved are observing and classifying. But in this paper, the basic science process skills involved are observing and communicating. Communication was involved in this study because that item is important to deaf students. The deaf students are expected to be able to communicate at a very basic level of what they have learned. Therefore, the situation is to bring forth students who are not only academically knowledgeable, but also those who can apply this knowledge contextually. This is only possible when students are trained to think critically and creatively starting at the primary level.

Augmented Reality in Education

Augmented Reality has extremely wide applications across a whole range of disciplines. It has been applied in many fields like videoconferencing (Barakonyi et al, 2003), entertainment (Barakonyi & Schmalstieg, 2005), training and education (Hughes et al., 2005). The systems provide students with a very rich source of educational materials in a form that makes learning exciting (Lui et al, 2006). Billinghurst (2002) said that the educational experience offered by Augmented Reality is different for a number of reasons which are:

i) Support of seamless interaction between real and virtual environment.
ii) The use of a tangible interface metaphor for object manipulation.
iii) The ability to shift smoothly between realities and virtual.

Besides that, AR can also be implemented in the classroom environment. This is because it can be in accordance to the teaching syllabus, suitable for the classroom environment and at the same time, motivate students, and made suitable for self-learning and robustness for the personal users by using markers (Lui et al, 2007b).

Therefore, by using AR, learning can be more attractive and interesting. Thus, students can capture knowledge faster and have a deeper impression of the subject learned (Lui et al, 2006).

Augmented Reality in Science Education

A significant number of AR has been implemented in many areas of application including education, from primary to tertiary. Some of the AR projects for Science education are such as basic concepts about plants and solar system (Lui et al, 2007b). In that studies the mixed reality applications in edutainment which has the potential to make learning and teaching more interesting and meaningful by making learners' experience more engaging. For example, a project that is called My Inside the Body Book (MIBB) (Nischelwitzer et al, 2007) has been developed using AR. The AR presents the human alimentary system in three dimensions. In addition, the user can interact with the software and manipulate the image, add and remove organs, by using the buttons mounted at the bottom of the book.

Even though AR could be applied to various domains of applications, the technology is projected to have more significant role in teaching and learning such as visualizing the abstract concepts in Science education (Mohd Nihra Haruzan Mohd Said & Norazlina Ismail, 2007), (D.R.Awang Rambli et al, 2007).

In addition, the interviews with teachers in deaf schools show that deaf students have problems with teaching and learning the abstract concepts in science education. Researchers like Passig & Eden (2000) have suggested that educators should be concerned about abstract thinking of deaf children.

Virtual Environment In Deaf

Only a few researches that are related to the deaf people in virtual environment (VE) have been conducted. A research by Daniel Hahn et al (2005) was about an assistive system for deaf people that consisted of a wearable microphone array and an Augmented Reality system. The system helped the users

in communication situation, and it was able to locate sound beacons in three-dimensional space. It determined the sound sources, which were in the user's focus of attention. The implementation of AR in this system was presented by the floating captions.

Besides augmented reality, virtual reality (VR) is also one of the elements in mixed reality. Below, a few researches have been carried out in virtual reality related to deaf and sign language. The Virtual Reality Applications Research Team (VIRART) has been specifying building and evaluating the virtual environments in special-needs education (Brown et al, 1997). One of the researches is develop a tool to teach Makaton Symbols. It contains a training program which uses VEs to teach Makaton symbols. Students learn the symbols and hand sign for the Makaton language system. Another work that is related was done by Geitz et al (1996) which was related to sign language. It was a teaching tool consisting of a collection of three dimensional computer graphics models representing American Sign Language manual alphabet hand shapes in various locations and orientation.

Another research in virtual reality related to deaf and science education is SMILE (Science and Math in an Immersive Learning Environment) project that has been done by Adamo et al (2006), Adamo-Villani & Wilbur (2007), Adamo-Villani & Wright (2007), Nicoletta et al (2006) and Raugust (2006). This project is an immersive game in which deaf and hearing children ages 5-10 learn math and science concepts and American Sign Language terminology through interaction with animated 3D characters and objects. The finding shows that learning by playing in VE can make the learning becoming more fun. Therefore (Brown et al, 1997) said that virtual environment, is a potential medium to be used in special education. It has been shown in those researches above. The virtual environment can be used in communication situation and sign language. It can also be used in education for the deaf. So, there is a need to develop an augmented reality for learning science for the deaf.

Augmented Reality Book

Augmented reality books (AR books) are a neo-millinnal style of learning for students to read in a meaningful learning environment to be better readers (Roslinda Ramli, 2009). AR book is one type of AR applications which looks like a normal book. The key element of this book allows users to read the book as normal book but at the same time, users are able to see virtual component superimposed over real book page in AR view (Grasset et al, 2008b).

Recent research that creates new types of visually enhanced books by using augmented reality was introduced by Billinghurst called "MagicBook" (Billinghurst et al, 2001). This prototype allows users to see the real world at the same time as virtual imagery attached to real locations and objects. AR technology allow users to shift from real world, augmented reality to immersive virtual (Billinghurst, 2002) . But nowadays, the AR book comprises of pattern markers in book, web camera and a notebook or laptop. In the notebook contains the database of pattern marker cards and database of virtual model.
This is illustrated in Figure 3 below.

Since this MagicBook has been successful, a few researches have already been developed. In 2002 an AR-book research was done by Fjeld & Voegtli. The research was about the advantages tangible interaction can bring to chemistry education (Fjeld & Voegtli, 2002). In New Zealand science centre museum, five projects related to education regarding the AR book were done. They were the black magic kiosk, the solar-system and orbit learning, the volcano kiosk, the historical artifacts and the eyeMagic virtual story book (Woods et al, 2004). Research regarding the technical parts such as magic lens in as an interface tool for AR interface (Looser et al, 2004) and handheld PC (Kikuo Asai et al, 2005). Meanwhile, in National Institute of Multimedia Education Japan, they already build the augmented reality text book, a mathematics instructional material and a museum display system (Kondo, 2007). Two research regarding to AR book which were related to cultural heritage (Walczak & Wojciechowski, 2005) and gaming (Juan et al, 2005) were developed. The augmented reality for teaching primary school science has been done by

Kerawalla (2006). Research physical controller were used in developing a low cost AR learning environment called My inside body book (Nischelwitzer et al, 2007). AR based story book which supports low ability reader in early literacy by using AR through exploratory, allow children to interact with it (Dunser, 2008; Dunser & Hornecker, 2007; Grasset et al, 2007; Grasset et al, 2008b; Hornecker & Dunser, 2007).

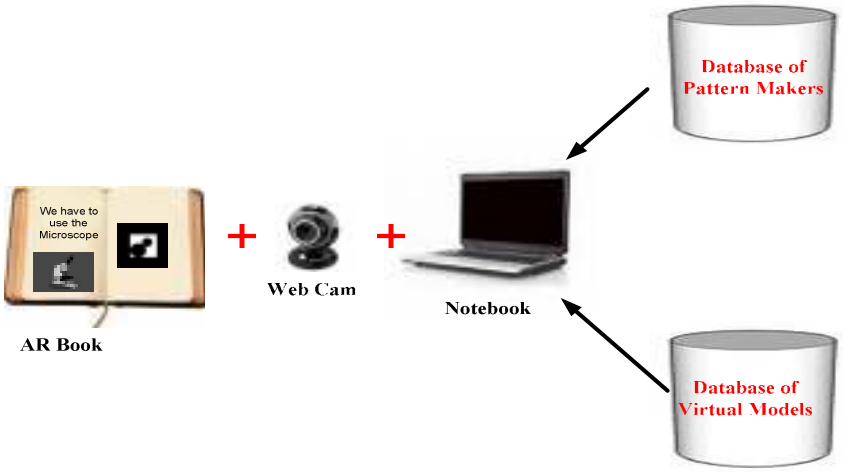


Figure 3 Essential Components of Augmented Reality Book

The above researches regarding AR book were more focused on education such as early literacy, storytelling and science education, cultural heritage and gaming. Therefore, there is a need for this research to embark into this area by applying the AR book in Science education for deaf.

Methodology

This research used a qualitative method. The data gathered through interviews technique and ethnographic method via observation was used to acquire the appropriate data.

Respondents

Three groups of respondents were involved in this study. They were officers, teachers, and deaf students. The officers were from Education Technology Department, Curriculum Development Centre and Special Education Department. The teachers were those taught Science to the deaf students, coordinators of Science subjects and headmasters or headmistress from the deaf schools. As for the observation, three deaf students (1 male and 2 female) were from the special education school for the deaf in Kampung Baharu, Kuala Lumpur. They were 12 years old, and considered as achievers by their teachers. They are now learning Year 5 Science subject. The teachers chose them because they are almost on par with each other. The parents' consent was asked before the observation was conducted.

Research Instrument

There were three instruments used in this study. The first and second were interviews, and the third was observation. The first instrument was Interview Schedules for Education Officers (ISEO). The researcher identified if there was any courseware or TV programs that has been developed for deaf students in Science subject. The researcher also inquired whether there was a special curriculum for deaf students.

The second instrument was Interview Schedule for Teachers (IST). Their experience in teaching and interacting with deaf students were asked. The researcher identified the common behaviors and cognitive problems faced by the deaf students in teaching and learning. Meanwhile, the third instrument was an observation and interaction with the deaf students. The instrument is Observational Check List for Deaf Student 2 (OCLDS2).

According to the acquisition in science process in Figure 2, the first construct is observing, the second construct is classifying and the sixth is the communication. But in this observation, just two basic science process skill involved, which were observing and communicating. Here deaf students have to make the sign language, finger spelling and write the text according to the pictures given by the researcher. They also had to choose suitable words according to the picture. There were five sets of pictures which they had to observe. For every set of pictures contained the sketch pictures, 2D pictures and real pictures. In this session, the researcher identified the common behaviors and cognitive problems faced by the deaf students in visualizing pictures and sign language. Besides that, the researcher also found out the similarities and differences between deaf students in acquisition in science process especially in classifying and communicating.

Research Procedure

The research procedure was conducted based on three phases as follows:

Phase 1: Obtain written permission from Ministry of Education and parents of the deaf students before the implementation of the observation.
Phase 2: The education officers and teachers of the deaf learners were interviewed based on the instruments built: ISEO and the IST respectively.
Phase 3: Working with the selected deaf students. An ethnography method had been used in this study. Video recording been analyzed to find the deaf students' learning behaviors. Firstly, the researcher gave a set of pictures which contained sketch picture, 2D picture and real picture. Secondly, according the picture given, the deaf students had to make the sign language, spell words by using finger spelling and write the word. Thirdly, they had to choose word that was related to the picture given. From there, deaf students had to rate the level of favoritism by using smiley icon card. By the sets of answer, the deaf students have to choose the reasons why they like or dislike the picture. This interaction and observation were handled by the researcher and supported by teachers who taught the deaf students.

Data Analysis

Due to the approach of this study which was qualitative, data from interviews were explained according to the group. The first group was officers by using the instrument built called ISEO. Meanwhile, second group was teachers dealing with deaf students by using the instrument built called IST.

At this phase, the ethnography method was used to analyze the observation and the interaction with the deaf students. The video recording was analyzed to identify the learning behaviors faced by the deaf students. The researcher also identified the similarities and differences faced by the deaf students. Observation of the learners was used based on visual literacy components which were visualization or visual thinking, visual learning and visual communication (Aanstoos & Academy, 2003; McLoughlin & Krakowski, 2001). In this observation, visual thinking referred to identifying words. On the other hand, visual communication referred to the use of sign language, finger spelling and written text.

Findings

Interviews with officers from three departments by using first instrument ISEO which were related to the education of deaf students, reported that there were no current courseware in science that were developed particularly for the deaf students. Besides that, the deaf students used the same syllabus and courseware as normal children did in normal primary school. It can be seen in Table 2. As a result, this

burdens the teachers who have to be creative in preparing the teaching and learning materials for the deaf students to ensure that the students understand the subject learned well.

Table 2 Result structured interview with officers

Factors	*Problems*
Material	There are still no courseware and televisyen program developed for the deaf students especially for Science subject. Have to use the same materials as normal students do, most material are text-based rather than visual-based. No expertise to develop this kind of courseware.
Curriculum	Deaf students are using the same curriculum as normal students do in primary school.

Results from the interview by using instrument IST with several teachers teaching and dealing with the deaf students can been seen in Table 3 below.

Table 3 Result structured interview with teachers who taught the deaf

Factors	*Problems*	*How teachers overcome this problem*
Students	Difficult to understand abstract words	Using picture because deaf student is visual learner.
	Limited cognitive ability	Repeat the syllabus; taking long time to finish up the syllabus
Teaching Method	Using the current method	Have to be creative in preparing the teaching material
Material	No specific courseware	Have to use sign languages to facilitate their teaching

From the interviews, the researcher gathered that problems faced by the deaf students were science literacy which concerned with the ability to read, write and count and also skills in science process. These skills were divided into two, the basic and the integrated. One of the examples of the problems faced by the deaf students was they could not understand the science-conceptual words such as habitat, photosynthesis, energy, alkaline, microorganism and others. These science-conceptual words were known as abstract words. To overcome this problem, teachers used pictures and explain them to the students. This however, was not an effective measure because the students had limited cognitive ability. To overcome this problem teachers always had to repeat the content that they already been taught the deaf students.In addition, their language proficiency was also a barrier, because they did not acquire both languages; English and Bahasa Melayu like normal children did. Therefore, they had to take longer time to read an instruction, sentence or paragraph. This result is the same as the previous researches result, which was conducted in United Kingdom (Adamo-Villani et al, 2006; Raugust, 2006).

Due to their limited cognitive ability, the deaf students had problems in understanding the science concepts introduced to them. They also had limited ability to remember what was thought to them. This situation was discovered in the previous research which was done by Abdullah Yusoff and Che Rabiaah Mohamed (2002). Besides that, Nor Hasbiah (2007) has found that, this situation also accured among the disleksia students. In addition, deaf students also were lacking in critical and creative thinking which were crucial in learning science topics. This statement were supported by Jamila (2007). To worsen the

situation, there was no sign language used to explain the concept, may it be the American Sign Language (ASL), *Kod Tangan Bahasa Melayu* (KTBM) or even in Bahasa *Isyarat Malaysia* (BIM) itself. Therefore, it was difficult for teachers and students to use the sign language.

Although teachers use multimedia technology such as using the CD-ROM which was supplied by the Curriculum Development Centre, they still had to use sign language to facilitate their teaching because the CD-ROM was meant for the normal students, not the deaf. Many teachers found the CD interesting. However, previous research also supported that normal courseware was not suitable for deaf students (Nor Hasbiah Ubaidullah, 2007; Sri Fatiany Abd Kader & Ismail, 2008).

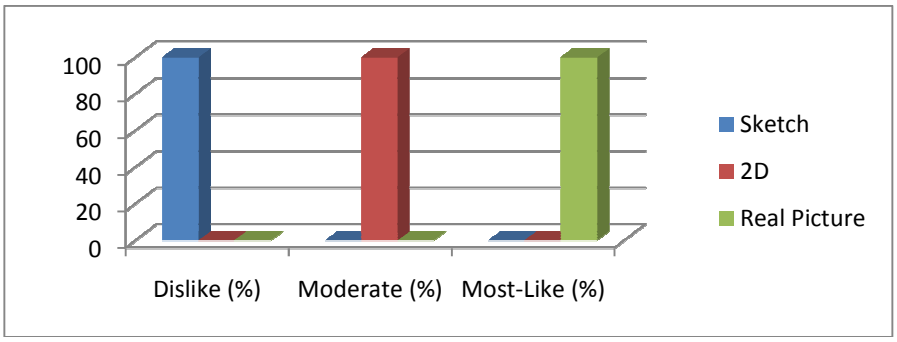
Unfortunately, the schools for the deaf were using the same syllabus as the normal school did. Thus, the deaf students were expected to achieve as what their normal counterparts did. This, however, could not be done due to the constrains that these student had. On top of that, being deaf not only affects the students' communication, it also affects their personal and social life. This statement were supported by a few researchers (Abdullah Yusoff & Che Rabiaah Mohamed, 2004; Jamila K.A. Mohamed, 2007).

From the interaction with the deaf students, the researcher acquired the learning behavior among them in learning science, particularly in visualizing the words and picture regarding the pre-requisite and the topic microorganisms itself. This can be seen in Table 4 below which shows students 1, 2 and 3. In visual thinking, it involved identifying text and picture, meanwhile in visual communication involved sign language, finger spelling and written text. Data was collected using the OCLDS2. Table 5 shows the reasons given by the deaf students meanwhile Table 6 illustrates the mistakes they made.

Table 4 Observation and interaction with three samples (student 1,2 and 3) on visual literacy.

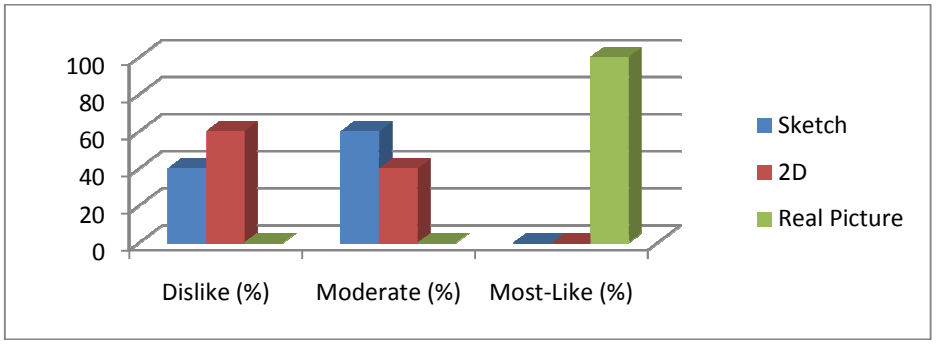
Student 1

Recognizing pictures	*Visualization (%)*	*Visual Communication (%)*		
	Words	Sign Language	Finger Spelling	Written Text
Pictures	100	100	80	100



Student 2

Recognizing pictures	*Visualization (%)*	*Visual Communication (%)*		
Pictures	Words	Sign Language	Finger Spelling	Written Text
	100	100	100	60



Student 3

Recognizing pictures	*Visualization (%)*	*Visual Communication (%)*		
Pictures	Words	Sign Language	Finger Spelling	Written Text
	100	100	80	80

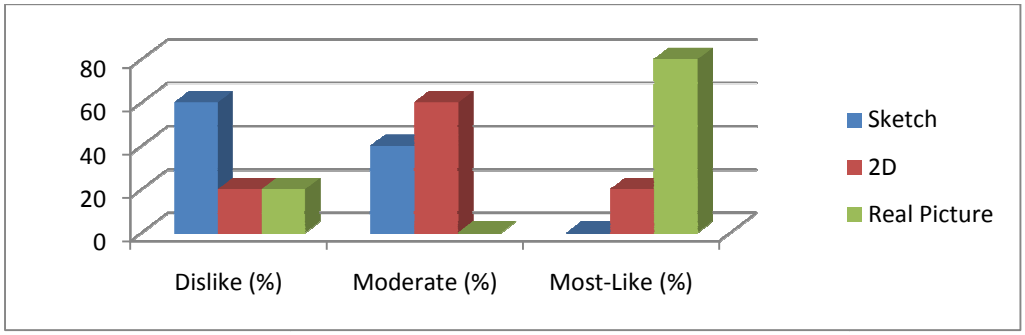


Table 5 Reasons given by deaf students

Picture dislike	***Picture most like***
• Ugly • No colors at all • Not many colors • Not clear • Not real picture • Colors not attract me	• Clear • Beautiful • Experience seeing picture • Seems delicious • Color attract me • Real picture • Understand picture

Table 6 The spelling mistakes makes by deaf students were

Picture given	***Spelling mistakes***
Watermelon	Watermolen
Grapes	Garpe , *anggur*
Butterfly	Butterful

From the table above, it can be observed that the three students share some similar characteristics as follows:

1. Deaf students are capable in visualizing picture.
2. They like picture in real pictures compared to 2D or sketch pictures.
3. They have good ability in visual communication such as sign language compared to finger spelling and written text.
4. If they are able to spell word by using finger spelling, they are also able to write it on.
5. They are able to give good reasons according to the picture given.

Discussion And Recommendation

From the result shown, the deaf students were capable or good in visualizing text. This statement was supported by the research, that was done by (Nurul Hijja Mazlan & Shaffe Mohd Daud, 2009) that deaf students can visualize simple text but could not understand if complex words or long sentences were used. Therefore, simple words and short sentences will be used in the AR-Book call AR-SiD. According to the percentage, real pictures gathered the highest percentage compared to the 2D and sketch pictures. So, in the development phase, the researcher will use 3-Dimensional (3D) models to make deaf students becoming interested to learn. The AR-SiD will have to include the sign language because the result showed that they have good ability in visual communication such as using sign language compared to finger spelling and written text.

Blended learning by using AR Book in Science for Deaf Learners.

Below are the strategies for improving visual literacy among deaf students and the proposed blended learning by using AR book called AR-SiD for deaf learners in learning science on the Microorganisms topic. The strategies are:

a) For AR-Book:
- Use 3D picture.
- Use color pictures.
- Use simple words.
- Use short sentences.
- Add in sign language.
- Big pictorial AR-Book.
- Integrated with text, pictures, sign language and 3D models.

b) For online learning:
- Capable to view the sign language and 3D model in web site.
- Printed worksheets for the deaf students to do some exercises such as matching pictures with words, organizing the correct letters, filling in the blank with the word given, and others.

The advantages of blended learning for AR-SiD, it can be used for both, classroom and home environment. This research was supported by researchers from Bloomsburg University of Pennsylvania (Slike et al., 2008). Students can look at the model and see the sign language in online learning. For the future research, deaf students can view the 3D model and sign language according to their free time with supervision from teachers or parents. This process will establish good relationship between deaf students and their family. During free time like during weekends or school holidays, they can also use the AR-SiD.

Realizing the deaf students are visual learners, they can use e-mail to ask the teachers if they have any question according the subject learnt during school holiday.

Conclusion

This study identified learning behavior among the deaf students' visual literacy in Science subject year five. It was aimed to design and develop Augmented Reality Book for the deaf in Science, Microorganisms topic by using blended learning strategies. This AR-Book is called Augmented Reality Book Science in Deaf (AR-SiD) which includes online learning that can interact with the AR-Book. The preliminary study conducted with the purpose of acquiring data for software requirement specification (SRS) was conducted using various instruments such as ISEO, IST and OCLDS2. Analysis carried out showed that deaf learners shared strong characteristic as visual learners. They favored real pictures more compared to 2D pictures or sketch pictures. It is expected that the 3D environment courseware in blended learning environment called AR-SiD is useful for visualizing abstract concepts in learning science; especially among deaf learners who are visually oriented. Moreover, previous studies showed that normal courseware were not suitable to the deaf students (Nor Hasbiah Ubaidullah, 2007; Sri Fatiany Abd Kader & Ismail, 2008). Some limitation might be related to data collection and interpretation of results. The first limitation is the sample of respondents. Only three deaf students were involved in the collection of data. This was due to the reason that it was rather difficult to get respondents who were of almost the same cognitive level and on par with one another in terms of their study performance. Another limitation is that only one instrument was being employed by the researcher to find out which picture did the deaf students were in favor of. Hopefully, this augmented reality technology by using blended learning approach can help deaf students to acquire visual literacy for learning science and acquiring the appropriate science process skill.

References

Aanstoos, J., & Academy, C. (2003, 15-17 October 2003). *Visual Literacy: An Overview.* Paper presented at the 32nd Applied Imagery Pattern Recognition Workshop (AIPR'03).

Abdullah Yusoff, & Che Rabiaah Mohamed. (2002). Proses Pendengaran dan Implikasi Kecacatan Pada Bahasa. *Dewan Bahasa, Ogos,* pp. 54-59.

Abdullah Yusoff, & Che Rabiaah Mohamed. (2004). Penguasaan Bahasa Melayu dalam Kalangan Murid Pekak: Suatu Sorotan dari Perspektif Lingustik. *Jurnal Dewan Bahasa*(Disember 2004), pp. 639-680.

Adamo-Villani, N., Carpenter, E., & Arns, L. (2006, 26-28 Jun). *3D Sign Language Mathematics In Immersive Environment.* Paper presented at the Proceedings of the 15th IASTED International Conference Applied Simulation and Modelling, Rhodes, Greece.

Adamo-Villani, N., & Wilbur, R. (2007). *An Immersive Game for K-5 Math and Science Education*. Paper presented at the 11 th International Conference Information Visualization (IV'07).

Adamo-Villani, N., & Wright, K. (2007). *SMILE: An Immersive Learning Game for Deaf and Hearing Children*. Paper presented at The 34th International Conference and Exhibition on Computer Graphics and Interactive Techniques. Retrieved January 2008,

Barakonyi, I., Frieb, W., & Schmalstieg, D. (2003, 30 June - 1 July). *Augmented Reality videoconferencing for collaborative work.* Paper presented at the 2nd Hungarian Conference in Computer Graphics and Geometery, Budapest, Hungary.

Barakonyi, I., & Schmalstieg, D. (2005, 19-21 September). *Augmented Reality agents in the development pipeline of computer entertainment.* Paper presented at the 4th International Conference on Entertainment Computer (ICEC'05), Sanda, Japan.

Billinghurst, M. (2002). Augmented Reality in Education. Retrieved 13 March, 2008, from www.newhorizons.org/strategies/technology/billinghurst.htm

Billinghurst, M., Kato, H., & Poupyrev, I. (2001). The MagicBook—Moving Seamlessly between Reality and Virtuality. *IEEE Computer Graphics and Applications, 21*(3), pp. 6-8.

Brown, D. J., Kerr, D., & Wilson, J. R. (1997, August). Virtual Environments in Special-Needs Education. *Communications of the ACM, 40,* pp. 72-75.

Chen, H.-R., & Huang, M.-J. (2009). *The effect of blended learning model for elementary school environmental education*. Paper presented at the First international workshop on Education technology and computer science

D.R.Awang Rambli, S.Sulaiman, & M.Y.Nayan. (2007, 2-5 November). *A Portable Augmented Reality Lab.* Paper presented at the 1st International Malaysian Educational Technology Convention (IMETC 2007), Skudai.

Dede, C. (2005). Planning for neomillennial learning styles. *Journal of Educase Quartely, 28*(1), pp. 7-12.

Dunser, A. (2008). *Supporting low ability reader with interactive augmented reality.* Paper presented at the Annual review of cyber therapy and telemedicine: changing the face of healthcare, San Diego.

Dunser, A., & Hornecker, E. (2007, 11-13 July). *An observational study of children interacting with an augmented story book.* Paper presented at the E-learning and games (Edutainment), CUHK, Hong Kong.

E.Shelton, B. (2002, December). Augmented Reality and education, current projects and potential for classroom learning. *New Horizons for Learning, 9*.

eLearners.com. (2007). Guide to online education. Retrieved 1 October, 2009, from http://www.elearners.com/guide-to-online-education/

Faaizah bt Shahbodin. (2008). *Pakej multimedia sains (nutrisi) menggunakan pendekatan pembelajaran berasaskan masalah secra Hibrid (C^2HADAM).* Kebangsaan Malaysia, Bangi.

Fjeld, M., & Voegtli, B. M. (2002). *Augmented chemistry: An interactive educational workbench*. Paper presented at the Proceedings of the 1st International Symposium on Mixed and Augmented Reality

Geitz, S., Hanson, T., & Maher, S. (1996). *Computer gentrated 3-dimensional models of manual alphabet handshapes for the World Wide Web*. Paper presented at the ASSETS '96. Retrieved 22 Aug 08,

Grasset, R., Billinghurst, M., Dunser, A., & Seichter, H. (2007). *The mixed reality book: A new multimedia reading exp.* . Paper presented at the CHI 2007 Interactivity.

Grasset, R., Dunser, A., & Billinghurst, M. (2008a). *The design of a mixed-reality book: Is it still a real book?* Paper presented at the ISMAR 2008. Retrieved Mac 2009 - Hit lab,

Grasset, R., Dunser, A., & Billinghurst, M. (2008b, 3-5 December). *Edutainment with a mixed reality book: A visually augmented illustrative childrens' book.* Paper presented at the ACE, Yokohama, Japan.

Hahn, D., Beutler, F., & Hanebeck, U. D. (2005, September). *Visual scene augmententation for enhanced human perception.* Paper presented at the 2nd Int. Conference on Informatics in Control, Automation and Robotics (ICINCO 2005), Barcelona, Spain.

Hornecker, E., & Dunser, A. (2007). *Supporting early literacy with augmented books-experience with an exploratory study.* Paper presented at the German society of informatics Jahrestagung.

Hughes, C. E., Stapleton, C. B., Hughes, D. E., & M.Smith, E. (2005). Mixed reality in education, entertainment, and training. *IEEE Computer Graphics and Applications, 6*(25), pp. 24-30.

Jabatan Pendidikan Khas. (2007). *Buku Maklumat Pendidikan Khas*. Kuala Lumpur: Jabatan Pendidikan Khaso. Document Number)

Jamila K.A. Mohamed. (2007). *Pendidikan Khas Untuk Kanak-kanak Istimewa*. Kuala Lumpur: PTS Professional Publishing.

Juan, M. C., Rey, B., Perez, D., Tomas, D., & Alcaniz, M. (2005). *The memory book*. Paper presented at the Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology.

Kerawalla, L., Luckin, R., Seljeflot, S., & Woolard, A. (2006). Making it real: Exploring the potential of augmented reality for teaching primary school science. *Virtual Reality, 10*(3), pp. 163-174.

Kikuo Asai, Hideaki Kobauashi, & Tomotsugu Kondo. (2005, 5-8 July). *Augmented instruction-a fusion of augmented reality and printed learning materals.* Paper presented at the Advanced Learning Technologies, Kaohsiung, Taiwan.

Kondo, T. (2007). *Augmented Learning Environment using Mixed Reality Technology*. from http://ship.nime.ac.jp/~tkondo/publication/elearn_article.pdf

Kyle, F. E., & Harris, M. (2006). Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing school children *Deaf studies and deaf education, Summer* (11), pp. 273-288.

Looser, J., Billinghurst, M., & Cockburn, A. (2004). *Through the Looking Glass: The User of Lenses as an Interface Tool for Augmented Reality Interfaces*. Paper presented at the Proc Computer Graphics and Interactive Techniques.

Lui, W., Cheok, A. D., Hwee, S., & Ivene, A. (2006). *Mixed Reality for fun learning in primary school*. Paper presented at the ACE 06. Retrieved July 2008,

Lui, W., Cheok, A. D., Mei-Ling, C. L., & Theng, Y.-L. (2007a). Mixed Reality classroom-learning from entertainment.

Lui, W., Cheok, A. D., Mei-Ling, C. L., & Theng, Y.-L. (2007b). *Mixed reality classroom - learning form entertainment.* Paper presented at the DIMEA '07, Perth, Western Australia.

Marshall, C. C. (2005). *Reading and interactivity in the digital libary: Creating an experience that transcends paper*. Paper presented at the CLIR.

Mayer, C. (2007). What really matters in the early literacy development of deaf children. *Deaf studies and deaf education, Fall* (12), pp. 411-431.

McLoughlin, C., & Krakowski, K. (2001, 23-26 September). *Technological tools for visual thinking: What does the research tell us?* Paper presented at the Apple University Consortium Academic and Developers Conference, Townsville.

Milgram, P., & Kishino, F. (1994). A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information Systems, E77-D*(12).

Mohd Nihra Haruzan Mohd Said, & Norazlina Binti Ismail. (2007, 2-5 November). *Overview of open source Augmented Reality Toolkit.* Paper presented at the 1 st International Malaysian Educational Technology Convention (IMETC 2007), Skudai Johor Malaysia.

Nicoletta, A.-V., Edward, C., & Laura, A. (2006). *An immersive virtual environment for learning sign language mathematics*. Paper presented at the ACM SIGGRAPH 2006 Educators program. Retrieved 31 Januari 2008,

Nischelwitzer, A., Lenz, F.-J., Searle, G., & Holizinger, A. (Eds.). (2007). *Some aspects of the development of low-cost Augmented Reality learning environments as examples for future interfaces in technology enhanced learning* (Vol. 4556).

Nor Hasbiah Ubaidullah. (2007). *Perisian kursus multimedia dalam literasi (D-Matematika) untuk pelajar disleksia.* Universiti Kebangsaan Malaysia, Bangi.

Norziha Megat Zainuddin, & Halimah Badioze Zaman. (2009, 20-22 July). *Augmented Reality in Science education for deaf students: Preliminary Analysis.* Paper presented at the Regional Conference on Special Needs Education Faculty of Education, University of Malaya.

Nurul Hijja Mazlan, & Shaffe Mohd Daud. (2009). *Electronic signing storybook (Doderead) for deaf students*. Paper presented at the Regional Conference on Special Needs Education.

Passig, D., & Eden, S. (2000). Improving flexible thinking in deaf and hard of hearing children with virtual reality technology. *American Annals of the Deaf, 145*(3), pp. 286.

R.Sherman, W., & B.Craig, A. (2003). *Understanding Virtual Reality*: Morgan Kaufmann Publishers.

Raugust, K. (2006, 27 September). Teaching the Deaf Through Animation. *Animation World Magazine*.

Roslinda Ramli. (2009). *Augmented reality technology in helping down syndrome learning in basic reading.* Paper presented at the Regional Conference on Special Needs Education

Sankey, M. (2006). *Transmodal delivery and neomillennial learning approaches*. Paper presented at the 4th International Lifelong Learning Conference: Livelong learning: Partners, Pathways and Pedagogies.

Sankey, M., & Hill, R. S. (2005). *Multimodal design for hybrid learning materials in a second level economics course*. Paper presented at the 11th Australasian Teaching Economics Conference.

Sankey, M. D. (2005). *Multimodal design and the neomillennial learner*. Paper presented at the OLT. Retrieved September 2009,

Slike, S. B., Berman, P. D., Kline, T., Rebilas, K., & Bosch, E. (2008). Providing online course opportunities foe learners who are deaf, hard of hearing or hearing. *American Annals of the Deaf, 153*(2), pp. 304 - 308.

Sri Fatiany Abd Kader, & Ismail, M. (2008, 5-7 November 2008). *Comprehending a story among deaf children: Is it ICT or conventional?* Paper presented at the 2nd IMETC, Ms Garden Kuantan.

Walczak, K., & Wojciechowski, R. (2005). *Dynamic creation of interactive mixed reality presentations*. Paper presented at the Proceedings of the ACM symposium on Virtual reality software and technology.

Woods, E., Billinghurst, M., Aldridge, G., & Garrire, B. (2004). *Augmented the science centre and museum experience*. Paper presented at the Proceedings of the 2nd international conference on Computer graphics and interactive techniques in Australasia and South East Asia.

Yoshinaga-Itano, C., Sedey, A. L., Coulter, D. K., & Mehl, A. L. (2006). Language of Early and Later-identified Children with Hearing Loss. *Pendiatrics Official Journal of the American Academy of Pendiatrics, 102*(5), pp. 1161-1171.

Young, J. R. (2002). Hybrid learning. Retrieved 3 October, 2009, from http://media.njit.edu/hybrid/