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Mobile Augmented Reality Learning Application for Students with Learning Disabilities

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Abstract
This study was carried out to develop a mobile augmented reality (AR) learning application, called *BadanKu*, to help students with learning disabilities to learn the topic of human anatomy. The development model used for the development of this novel application was the ADDIE model. A suite of development software, namely Adobe Photoshop, Unity, and Vuforia, were used to develop this mobile AR learning application consisting of several multimedia elements, such as text, audio, graphic, video, and animation. A virtual human body was designed to show the three major parts of the human anatomy, namely the head, torso, and limbs. This learning application was developed to help teachers of the *self-management* subject to teach such a topic to year-one primary school students with learning disabilities, whose ages range from 7 to 9 years. These teachers can use the smartphone camera to scan those parts of the human anatomy shown on the application's user interface to display the learning contents to students, with which the latter can interact with to learn all aspects of such body parts. Clearly, teachers can leverage learning activities of students with learning disabilities with the use of mobile AR learning applications with multimedia elements, such as audio, graphics, animation, and video, the impact of which can make such students highly motivated, active, and interested in the learning process.
Keywords: Augmented Reality, Learning Disabilities, Mobile Learning Application, Multimedia Elements, And Primary School Students.

Introduction

Over recent years, the educational landscape is flooded by many mobile applications, with each being developed for specific objectives. Studies have shown that such novel applications have made learning and training not only more effective but also more entertaining. Their pervasive use is not surprising given that mobile applications can run on many devices, including personal computers, smartphones, and tablets, operating on multiple platforms. To date, many development tools are available to help users to develop their own applications. For example, *Unity*, a popular learning application development tool, has been widely used to create Augmented Reality (AR) educational

games in tandem with current technological developments. The AR technology is not really new, as it has been in existence for almost five decades. Of late, however, the continual advancement of such technology has intensified its use in various fields, notably in the educational realm (Yusoff et al., 2018). In principle, AR technology supports a diverse range of multimedia elements, such as graphics, texts, video, animations, and audio (Yusoff et al., 2018; Hussaini, Bakar, Yusuf, 2018). More importantly, it is a technology that can enrich a real-world scene as seen through the camera of digital devices (such as smartphones, tablets, and PCs) by overlaying digital media, such as 3D models or video, on such a scene. As such, the AR technology is as a technology that projects computer-generated virtual images or information on the real world directly in real-time (Azuma, 1997). Some studies have synthesized the findings of previous studies and pointed out that AR applications have a positive effect on educational outcomes such as learning achievement, attitude, motivation, attention, and retention in learning process (Mustafa & Tuncel, 2019). As such, a study of learning applications for children with learning disabilities issues using Augmented Reality (AR) applications is important to be examined because this group of children required an interesting learning approach and by developing this apps gives positive value to children with learning disabilities. This study also found many studies was develop AR for disable people, this shows the importance of the AR learning application for people with learning disabilities. This rresearcher developed application for learning disabilities which is 7-9 years old student.

Objective

The objectives of this project are as follows:
To develop an AR learning application for children with learning disabilities in learning self-management for the topic of human anatomy.
To examine the impacts of multimedia elements used in the AR learning application on student learning.

Scope

The scope of this project was defined by a number of factors prevailing at the time it was carried out. As such, this project was carried out as follows:

Children with learning disabilities, whose ages ranged from 7 to 9, were recruited for this project.
Only one such child was examined at one particular time of a learning session.
The AR learning application was developed as a simple mobile AR game-based learning application.
The character of the learning application consisted of three parts, namely head, torso, and limbs, using multimedia elements, such as graphics, video, and animation.

Literature Review

The literature review carried out helped the researchers to examine the type of multimedia elements used in AR applications for children normal. The same review showed several applications have been developed for children with learning disabilities, with each having several similar concepts but with specific features. Table 1 summarizes the types of technology, multimedia elements, categories of research subjects, and the field and learning activities of the AR applications used in previous studies.

Table 1: Studies of Augmented Reality applications

Application / Year	Technology	Multimedia element	Research subject	Field	Learning activity/outcome
1. Puzzle by Lin et al., (2016).	Smart-phone and tablet.	Graphics, animation, and video.	Children with learning disabilities.	Special education.	A game entailing child with learning disabilities to arrange pieces of a puzzle aided by AR video.
2. Lin et al., (2015).	Webcam and computer.	Graphics and sound.	Children with learning disabilities.	Special education.	The study involved physical bodily movements as children moved into an area captured by a webcam, which generated accompanying images and sound to increase their motivation.
3. AR self-facial modelling by (Chen, Lee & Lin, 2015)	Webcam and Computer.	Animation.	Children with autism spectrum disorder.	Developmental disabilities.	The children displayed six facial expressions based on AR-3D animations of emotional expressions. The aim of the study was to impart knowledge concerning human emotions to students.
4. FenAR by Mustafa and Tuncel (2019)	Tablets.	Texts, graphics, animations, and sound.	Ordinary children.	Computer and education.	This AR tool, consisting of 10 applications, was used to detect students' learning disabilities and their attitudes toward the learning of Physic. Such a learning tool was also used to improve students' attention by using animal-like animations with sound.
5. Smart shelf by Rashid et al., (2017)	Tablets and smartphones.	Texts and graphics.	Wheelchair users.	Engineering and science.	This application assisted patients with low mobility on wheelchairs to locate goods or items during shopping.

As highlighted in the review, several AR applications with a diverse range of multimedia elements have been used in most studies. Table 2 summarizes the multimedia elements used in the AR applications.

Table 2: Multimedia elements used in Augmented Reality (AR) applications

Application / Year	Research subject	Multimedia element				
		Text	Audio	Graphic	Animation	Video
1. Puzzle by Lin et al., (2016).	Children with learning disabilities.	x	x	/	/	/
2. Lin et al., (2015).	Children with learning disabilities.	x	/	/	x	x
3. AR self-facial modelling by (Chen, Lee & Lin, 2015).	Children with autism spectrum disorder.	x	x	x	/	x
4. FenAR by Mustafa and Tuncel (2019).	Ordinary children.	/	/	/	/	x
5. Smart shelf by Rashid et al., (2017).	Wheelchair users.	/	x	/	x	x

As shown, multimedia elements used in AR applications in studies that focused on children with learning disabilities were primarily audio, graphic, animation, and video. Whereas, the animation was the multimedia element used in AR applications in studies that focused on children with an autism spectrum disorder. In addition, studies that focused on physically challenged children involved AR applications that relied on graphics and texts only. Moreover, some studies used study samples consisting of normal children and children with learning disabilities to determine the differences in the use of multimedia elements between such groups of research subjects. The review in such studies clearly showed that most AR applications used several multimedia elements, namely text, graphics, audio, and video, (Lee, 2007; Nayan, Mahat, Hashim, Saleh & Norkhaidi, 2018). The integration of such elements with a variety of colors can help create applications' interfaces that can stimulate students' senses that can wield a huge impact on the learning process among students, especially those with a low level of cognitive skills or knowledge (Sharifah, 2013). Such a contention is echoed by Lee (2007), who asserts that use of multimedia technology can have a positive impact on learning for students with learning disabilities.

Implementation

In many studies, researchers need to select an appropriate research methodology consisting of several components, such as phases, concepts, techniques, methods, and tools, to help them deal with a host of research problems. The use of such a methodology can certainly help ascertain the smooth implementation of such components in the research undertaking. The ADDIE model was also used to guide the development of the mobile AR learning application. This application development consists of five phases, namely analysis, design, development, implementation, and evaluation. Table 3 summarizes the tasks carried out in the development phases of the mobile AR learning application based on the ADDIE model. Figure 1 shows the flowchart of the mobile AR learning application.

Table 3: The development phases of the mobile AR learning application based on the ADDIE model

Phase	Task
Analysis	i. Analyze and determine learning objectives. ii. Analyze learning materials and study background. iii. Analyze mobile learning. iv. Analyze the learning environment that is suitable for the classroom.
Design	i. Design learning that uses multimedia elements, such as text, graphic, audio, animation, and video. ii. Design application using *vuforia*.
Development	i. Develop learning contents consisting of multimedia elements using *vuforia*.
Implementation	i. Implement the mobile AR learning application, called *Badanku*, on the mobile platform and implement an equivalent application on the desktop platform. ii. Implement learning in the classroom.
Evaluation	i. Evaluate the usability of the application. ii. Collect feedback regarding user acceptance of the application from users through observations

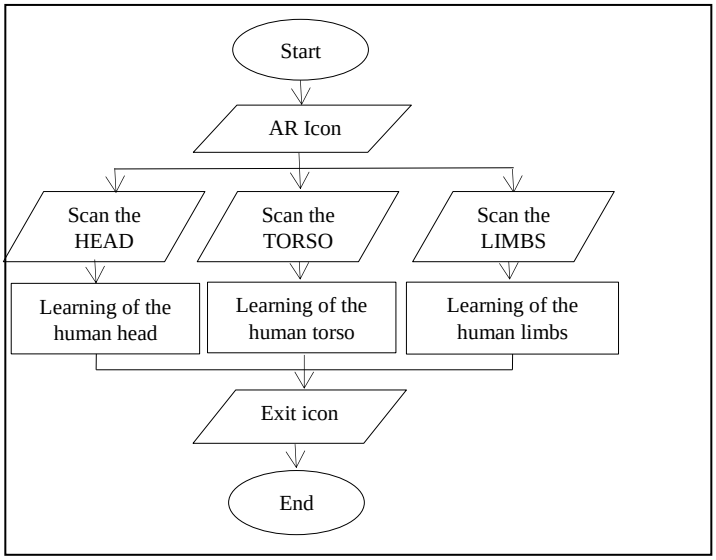

Figure 1. The flowchart of the mobile AR learning application

Figure 3 shows a diagram that represents the working flow or process of the mobile AR learning application (BadanKu). Users (e.g., teachers) need to scan the head or the torso or the limbs of the virtual human body using their tablets or smartphones. Once scanned, the learning of a topic relating to the scanned part of the virtual human body can take place. If the users wish to terminate the learning session, they need to click the 'Exit' button. Otherwise, they need to scan the other parts of the virtual human body to continue learning. Once they have learned the required topics, they can stop the learning process by clicking the 'End' button.

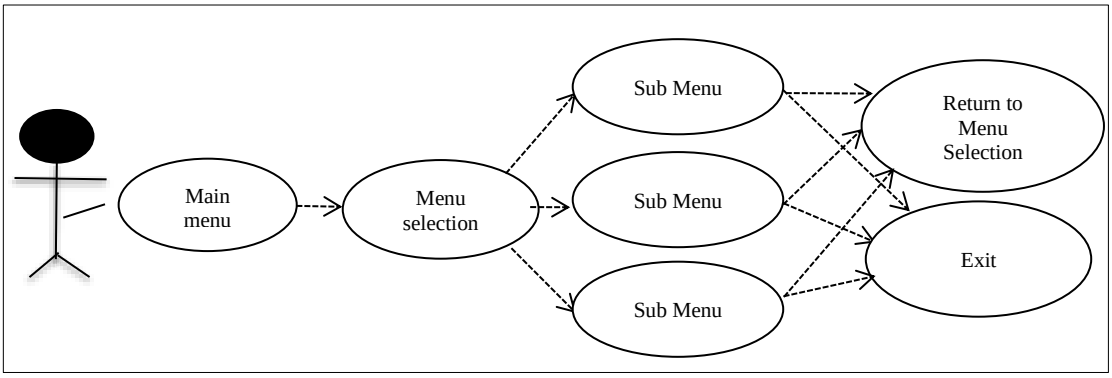

Figure 2. Menu selection of the mobile AR learning application

The Outcome of the Project

Figure 3 shows the main interface of the mobile AR learning application to help children with learning disabilities learn the topic of the human body for the subject of self-management. Such a user-friendly interface can help such students use this application with a high degree of efficiency and ease of use.

Figure 3. The main interface of the mobile AR learning application

Conclusion

As acknowledged, technology-enabled learning can have a huge impact on the learning efficacy of students, especially young children with learning disabilities. Such kind of learning is not only effective but entertaining as well. Over recent years, the use of Augmented Reality (AR) technology and multimedia elements in the development of learning and training applications has intensified, signifying the many educational benefits to which both learners and educators can gain. In particular, teachers can leverage learning activities of students with learning disabilities with the use of mobile AR learning applications with multimedia elements, such as audio, graphics, animation, and video, by making them highly motivated and interested in the learning process. However, to realize such an impact, application developers have to carefully consider all aspects that are important for the development of novel learning applications. For example, Sidek, Fathil, Zain & Muhammad (2014); Benard & Felicia, (2015) assert that the development of an effective user interface of a learning application for children with autism entails minimal use of texts, attractive graphics (to attract students' attention), interactive animations (to stimulate students' interest), simple and easy navigation, user-friendly interface, and relevant learning contents. Given the continual advancement in mobile technology, mobile devices, such as smartphones and tablets, are becoming not only affordable but also powerful, of which their utility can be further leveraged by running a wide spectrum of technologies, including AR technology, on such devices. Admittedly, many researchers have made numerous efforts to improve the effectiveness of AR learning applications in a wide range of disciplines, a majority of which were mainly dedicated to helping normal students. Hence, more efforts are needed to develop and use mobile AR learning applications for students who are cognitively challenged as emerging evidence suggests that learning using such technology will have a positive impact on their learning in that they can become more active and motivated.

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