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A User Study on Virtual Tutor Mobile Augmented Reality from Undergraduate Medical Student Perspectives

Kajian Penggunaan Aplikasi Guru Maya Realiti Meningkatkan untuk Perspektif Pelajar Perubatan Ijazah Sarjana Muda

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ABSTRACT

Mobile Augmented Reality (MAR) is another fascinating educational innovation with broad potential. It allows for new educational tactics, particularly in medicine. The concept of MAR can help learning activities in several ways, including allowing faster access to information in the mobile platform, increasing student motivation, making the learning process easier and more efficient, and aiding students in better understanding important concepts. However, three things needed to be considered: interface design, the usefulness of Augmented Reality (AR), technical problems with the use of AR applications, and teacher training on the use of AR applications. Without a well-designed interface and guidance for the students, AR technology can be too complicated to use, especially for those who are not familiar with the technology. An interface should be easy to remember and learnt by the user on how to best utilize it. In this study, we present a virtual tutor in the tutorial section, named Otus, which aids the students on how to use a MAR application called BARA (Brain Anatomy Revision Application). Our goal is to create a fluid interface flow in this MAR application for education that includes a virtual tutor. By including a virtual tutor, users can quickly increase their comprehension of how to use the application on their own. We ran an experiment to evaluate the usefulness of the Otus, comparing two groups: one was the experimental group, which consisted of 12 students using BARA with Otus in the tutorial, and the other was control group, which consisted of 12 students using BARA without Otus. We concluded from our questionnaire and observations that the experimental group was able to experience AR step by step and required more time to navigate the MAR app.

Keywords: Augmented reality, interface flow, medical learning, mobile platform, virtual tutor

ABSTRAK

Realiti Meningkatkan Mudah Alih (MAR) merupakan inovasi pendidikan yang menarik dengan potensi yang luas. Ia membolehkan taktik-taktik pendidikan baharu, terutamanya dalam bidang perubatan. Konsep MAR dapat membantu aktiviti pembelajaran dalam pelbagai cara, termasuk membenarkan akses lebih cepat kepada maklumat dalam platform mudah alih, meningkatkan motivasi pelajar, menjadikan proses pembelajaran lebih mudah dan berkesan, serta membantu pelajar memahami konsep-konsep penting dengan lebih baik. Walau bagaimanapun, terdapat tiga perkara yang perlu dipertimbangkan: reka bentuk antaramuka, kegunaan Realiti Meningkatkan (AR), masalah teknikal dengan penggunaan aplikasi AR, dan latihan guru dalam penggunaan aplikasi AR. Tanpa antaramuka yang direka bentuk dengan baik dan panduan untuk pelajar, teknologi AR boleh menjadi terlalu rumit untuk digunakan, terutamanya bagi mereka yang tidak terbiasa dengan teknologi ini. Antaramuka harus mudah diingat dan dipelajari oleh pengguna untuk menggunakan dengan baik. Dalam kajian ini, kami membentangkan sebuah tutor maya dalam bahagian tutorial, yang dinamakan Otus, yang membantu pelajar untuk menggunakan aplikasi MAR yang dipanggil BARA (Aplikasi Penyemakan Anatomi Otak). Tujuan kami adalah untuk mencipta aliran antaramuka yang lancar dalam aplikasi MAR ini untuk pendidikan yang merangkumi tutor maya. Dengan menyertakan tutor maya, pengguna dapat meningkatkan pemahaman mereka tentang cara menggunakan aplikasi ini dengan cepat. Kami menjalankan satu eksperimen untuk menilai kegunaan Otus, membandingkan dua kumpulan: satu kumpulan adalah kumpulan eksperimen, yang terdiri daripada 12 pelajar yang menggunakan BARA dengan Otus dalam tutorial, dan kumpulan lain adalah kumpulan kawalan, yang terdiri daripada 12 pelajar yang menggunakan BARA tanpa Otus. Kami membuat kesimpulan daripada soal selidik dan pemerhatian kami bahawa kumpulan eksperimen dapat mengalami AR langkah demi langkah dan memerlukan lebih banyak masa untuk mengembara dalam aplikasi MAR.

Kata kunci: Realiti terimbuh, aliran antaramuka, pembelajaran perubatan, platform mudah alih, tutor maya

INTRODUCTION

Nowadays, the use of AR technology has had a significant impact on various industries, particularly in the educational field. It is currently widely used in teaching and learning from elementary school to college. AR is a low-cost technology that can readily be implemented in educational settings. Several studies have recognised the potential of AR for improving learning and teaching (Billinghurst & Dünser 2012; Diegmann et al. 2015; Dunleavy et al. 2009; Garrett et al. 2015). AR applications are progressively showing up on mobile platforms. There are a few advantages of using MAR as a medium for learning where AR will help upgrade the learning experience by using 3D virtual objects for students to view these objects using their eyesight with various mobile interfaces. This enables the student to visualize the learning material more clearly with the assistance of a 3D object and interaction to see how a specific object would react. Students can use smartphones and tablets to interact with AR objects. Affordable mobile phones today are capable of supporting AR, thanks to their multi-core processors, graphics processing units (GPU), high-resolution cameras, and quick network connections (Leung et al. 2019). One of the challenges is that the stability of mobile AR technology cannot be assured, and difficulties may arise if the technology lacks well-designed interfaces and guidance, as this could make the technology too complex (Akçayır & Gökçe 2017; Wu et al. 2013). Users may require additional time to become familiar and comfortable with AR technology (Gopalan et al. 2016).

AR technology is becoming increasingly popular in medical learning since students are advancing to a new level of interaction with the technologies. In a medical programme, students who learn human anatomy use textbooks, two-dimensional static images, diagrams, and through dissection of cadavers. Studying medical education needs students to learn complex structures of anatomy. By proposing MAR in this learning, it helps students use both text & images and 3D models by using their smartphone to do a revision at anywhere and anytime, thus helping them gain a better understanding in learning. However, there is still a lack of awareness and understanding of MAR, and many students are unfamiliar with how to use the AR technology. According to Yuan et al. (2011), while implementing new technology in the learning system, the system function and operation process must be more straightforward for learners to understand. Users of AR technology may encounter technical difficulties and usability challenges, and some students may find this technology difficult to understand. (Akçayır & Gökçe 2017).

Therefore, the virtual tutor enables users to improve their understanding of using the application independently without any difficulties. One of the main advantages of using virtual tutor is that they are suitable for courses that do not have teachers available. Virtual tutor systems are computer programmes that assist a human tutor in performing a certain duty, such as indicating content, explaining concepts, or motivating students. (Alan & Eduardo 2019). Pedagogical agents in multimedia learning have become a new paradigm for education and training. These agents provide a novel metaphor for human-computer interaction with their image, appearance, message, voice, and interactivity (Chen & Chou 2015). Pedagogical agents are seen as anthropomorphic virtual characters mainly used for educational or training purposes. Yongheng et al. (2021) conducted a semi-open learning environment by using virtual tutor and exploratory guidance to help students to learn the virtual experiment. Their findings showed that the group with the virtual tutor and exploratory guidance had lower error rate, less cost time, and higher scores in experiment knowledge than the group without the virtual tutor and exploratory guidance. The availability of a virtual tutor was also welcomed by users, which is conducive to the teaching work of virtual experimentation. Yongheng et al. (2021) stated that adding virtual tutors and exploratory guidance to virtual experiments can improve the efficiency of experiments and the reliability of virtual education. In this user study, we present a virtual tutor, named Otus, which assists the students on how to use a MAR application, named BARA (Brain Anatomy Revision Application). Thus, with the introduction of a virtual tutor for medical learning in MAR application, it will improve the smoothness of the interface flow for users to use the application without any difficulties.

RELATED WORKS

Mobile Augmented Reality

AR's usefulness can be considerably boosted when it is integrated with other technologies, such as a mobile device. In education, mobile augmented reality (MAR) has the potential to improve the learning experience. It should be based on its usability and properly incorporated into the learning environment. Furthermore, according to Kamhphuis et al. (2014), mobile learning activities give students the flexibility to learn whenever and wherever they want. The concept of MAR can aid learning activities in a variety of ways, including helping faster access to material, increasing student motivation, making the learning process easier and more efficient, and helping students in better understanding concepts (Chehimi et al. 2007; Norman et al. 2012).

In 2013, FitzGerald et al. presented a study on augmented reality in the context of mobile learning, in which they looked at six mobile learning systems including augmented reality as a primary part. The six factors in their comparison taxonomy, which mostly focused on non-technical characteristics, were device/technology, mode of interaction/learning design, system of sensory input, personal/shared experience, fixed/static or movable experience, and learning activities. In addition to contrasting the six systems, FitzGerald et al. investigated pedagogical and technical difficulties that might need to be addressed when educational mobile AR systems are deployed. In a more design-oriented examination, Specht et al. (2011) looked at a variety of mobile AR applications and addressed their usefulness to learning. The authors recommended merging interaction design patterns with educational patterns for creating educational mobile AR apps, as well as detailing how diverse user context data might be used to contextualize the AR learning experience.

Usability

Users of AR technology may encounter technical difficulties and usability challenges, and some students may find this technology difficult to understand, according to Akçayr and Gökçe (2017). They also claimed that one of the most difficult parts of AR applications is usability; nevertheless, ease of use is also mentioned as a benefit. There is no evidence that AR technology causes usability issues; rather, they could be caused by a lack of technology understanding, interface design faults, technical challenges, or bad attitudes (Akçayr & Gökçe 2017). One of the characteristics of usability is learnability, or the ability to learn quickly. Learnability is described by Shackel (2009) as the ease with which a user may start and discover new aspects of the system. The ease with which a user can use a product or system (learnability) shows how simple it is for the user to use the product or system and whether the user can readily understand how to use it. The system must be intuitive enough to be used for the first time. The efficiency of usage describes how quickly a person can complete a job after learning how to use a product or system. After not using a product or system for a certain period, the user's ability to remember its function and usage is measured.

In the field of Human-Computer Interaction (HCI), usability is a key concept. Its widely accepted definition is provided in the standard International Organization for Standardization (ISO) 9241-210: 2019, 3.13: "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." According to ISO 9241–11, usability is described as a system's effectiveness, efficiency, and satisfaction (2018). These three criteria determine a device's or product's usefulness. Effectiveness refers to a user's ability to accomplish goals using a product. Efficiency is defined as the amount of effort a user spends to execute a task, which can be measured in terms of time spent on the task or speed of use. Satisfaction refers to a user's feelings about a product's usability.

Virtual Tutor

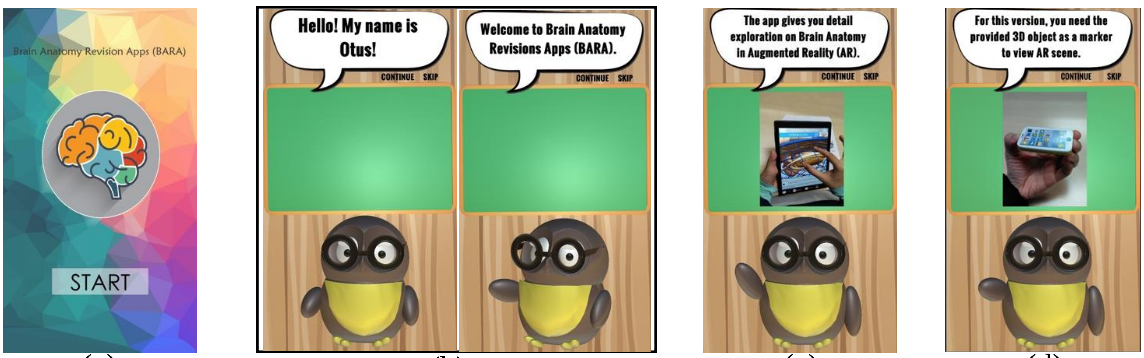
Pedagogical agents, according to Veletsianos and Russell (2014), are humanoid virtual characters employed in online learning settings to achieve a variety of educational goals that aid learning. In terms of design, Reatgui et al. (2007) defined pedagogical agents as human-like characters available in instruction software that promote learning, while (Yilmaz & Kilic-Cakmak 2011) classified pedagogical agents as human, human-like, sound-based, text-based, cartoon character-based, and intelligent, assistant, informative, assessor, pedagogical, advisor, and expert. Rather than just conveying complicated scientific knowledge, studies on agent-based learning have paid insufficient attention to how agents might work as a communicative or interactive bridge that supports students in understanding it (Plant et al. 2009; Rosenberg-Kima, Baylor, Plant, & Doerr 2008).

The interactive virtual tutor was designed to aid in the teaching-learning process in the classroom, not as a replacement for a human tutor or instructor, but as a pedagogical aid. In comparison to students who did not have access to the agent, (Chen & Chou 2015) found that students who had access to the agent successfully boosted their acceptance of knowledge. In addition, Hsieh and Chen (2019) revealed that their Intelligent Augmented Reality Tutoring System was well received by the student (IARTS). Guidance and personalisation, according to them, were the keys to increasing learning motivation and engagement. With the help of IARTS, the learning environment for students becomes more interactive and enjoyable.

MATERIAL AND METHOD

For this user study, we designed a tutorial section where the virtual tutor named Otus explained how to use the application simply. We assumed that there were possibilities that the instruction from the virtual tutor at the beginning of the application would enable users to better understand how to use the AR in any MAR application without the need for human support, especially for educational development. Virtual tutors can help minimize the need for human teachers while also allowing students to use a variety of learning techniques, potentially improving student engagement and experience (Thiago Reis et al. 2015). In this study, we employed the Brain Anatomy Revisions Application (BARA) mobile application by inserting and utilizing Otus characters. BARA is a mobile app that we developed for an undergraduate medical student as part of an earlier research project to teach brain anatomy using AR. We previously built and evaluated three variants of BARAs: a printed note with markers, a digital note with markers, and a 3D object marker with all the notes in the mobile app. The third version was chosen by most of the participants in an earlier study.

The Otus aides' users through animated movements, texts, images, and audio. The principles of multimedia, personalization, voice, and image concepts were considered to promote environments that ease germane loads (Wilson 2015). Otus demonstrated how to utilise the application to the user. The participants were given a brief explanation at the start of the application. The BARA instructional interfaces with Otus as a virtual tutor are shown in Figure 1. In the dialogue window that displays with the audio, the animated text will appear. Then, on pages dedicated only to the explanation, a series of graphics instructing the user on how to utilize the AR component will show; participants must click the "CONTINUE" button to go to the next page. The participants might also press the "SKIP" button the next time they open the BARA.



(a) (b) (c) (d)

(b)

(e) (f) (g)

FIGURE 1. Interfaces of the tutorial part in BARA. (a) Start page (b) Welcoming page in BARA (c) Inform the apps in AR (d) Explain the provided marker (e) Explain the icon (f) Guide user on how to use the AR (g) Make sure has proper lighting

We have implemented this by using Unity 2019, the most popular cross-platform game engine from Unity Technologies. For the Otus's 3D model and the animation of the Otus's movement, we developed using Blender, the 3D computer graphics software tool set used for modeling, rigging, animation, simulation, rendering, compositing and motion tracking. The 3D model of Otus is shown in Figure 2. The concept we came up with was for Otus to act as an aid in the tutorial section of the apps at the start. The Otus then demonstrated how to utilize the apps and pointed out which icon users should click, with the offered object being a marker. As mentioned by Alan and Eduardo (2018), students are encouraged to practice and complete a task order by listing the contents through screen transitions produced by tutor model that resemble the appearance of an instructor.

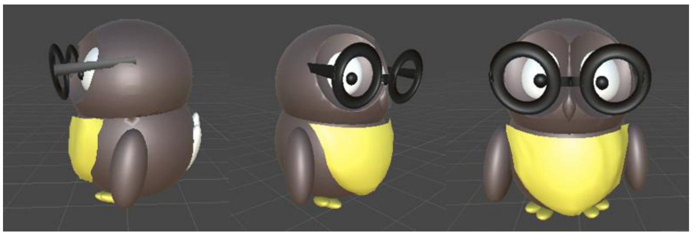


FIGURE 2. The 3D Model of Otus from front and side view

PRELIMINARY STUDY

There were four sessions in this research. The participants were asked to fill out a consent form and the purpose of the experiment was explained at the first session. They used a given tablet and a 3D marker in the second session to try out the BARA apps. After that, participants were directed to a link where they were asked to complete a questionnaire. Finally, we conducted a short interview with each participant and captured their audio. The methods of observation, questionnaire, and short interview were used in this experiment. The researchers' goals for this experiment were to (1) learn about students' experiences with medical learning in the MAR application; (2) understand the value of a virtual instructor as a learning companion; and (3) evaluate the application for improved improvement.

Participants

We invited 24 undergraduate students from UPM to take part in this study. They were UPM Faculty of Medicine and Health Science undergraduate medical students in their second year of school. Most had no prior experience with AR. Because the application focused on the module of brain anatomy that they will learn in the following semester, medical students were chosen as participants. To reduce any potential sample bias, students were randomly separated into two groups of 12 students each, referred to as experimental group and control group. This allowed a consistent cause and effect relationship to be formed (Fraenkel et al., 2012). Table 1 shows the demographics of the distinct categories.

TABLE 1. Demographic Information of The Groups

Group	Number of Participants	Male	Female
Experimental group	12	3	9
Control group	12	2	10

Set-up and Equipment

The study was conducted at the UPM Faculty of Medicine and Health Science's *Bilik Unit Penyelidikan & Inovasi Pendidikan Perubatan* (MERIU). The participants were situated in a relaxed environment with a chair and a table. A tablet and a marker were placed on the table. Two rooms, Room A and Room B, were used independently. Figures 3(a)&(b) depict the experiment setup, while Figures 3(c)&(d) depict the participant setup.

(a) (b) (c) (d)

FIGURE 3. The Experiment Arrangement. (a) Settings in Room A, (b) Settings in Room B, (c) View during the experiment in Room A, and (d) View during the experiment in Room B

The evaluation sessions were recorded with four Go-Pro Hero Black 5 cameras: (a) two zoom-out cameras to capture the entire front view of participants to record their facial expressions; (b) two zoom-in cameras to capture close-ups on the tablet activities to get a clear view of the tablet display and their hand gestures; and (c) two zoom-in cameras to capture close-ups on the tablet activities to get a clear view of the tablet display and their hand gestures; and tripod stands. Four Lenovo tablets were used, two tablets with installed BARA application for the participants and another two tablets used to audiotape the interview for transcription and data analyses. Two BARA’s markers using 3D objects were prepared for participants to experience the AR. The equipment’s set-up can be seen in Figure 4.

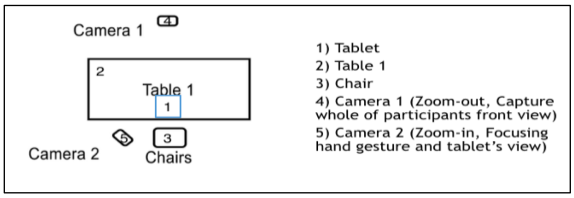


FIGURE 4. The set-up of The Experiment

Procedure

The experimental procedure is illustrated in Figure 5. There are a total of 24 undergraduate medical students who were divided into two groups with each of the groups containing 12 participants. There are two different rooms for each group. The random sampling technique was used to assign students into either the experimental or control group. For control group were in Room A, the participants were provided the BARA without the virtual tutor of the tutorial, while for experimental group were in Room B, the participants were provided BARA with the virtual tutor of the tutorial. This session was conducted simultaneously. The researcher explained how the experiment will be conducted and the procedure of the investigation, which included the purpose and the importance of this study. Each participant will be equipped with a tablet and a 3D marker. The researchers started the experiment by reading the task instruction: "Y*ou are now required to open the BARA and explore it. You can refer to the task sheet on the table. Please close the BARA once you are done and put the tablet on the table".* The researchers only interrupt the session once the participants are done. After the experiment finished, researchers asked participants to fill in a questionnaire via google form with the given link in the task's sheet. Upon completion of the above process, a short face-to-face interview was conducted and moderated by the researcher to gather their opinions and suggestions for future improvement.

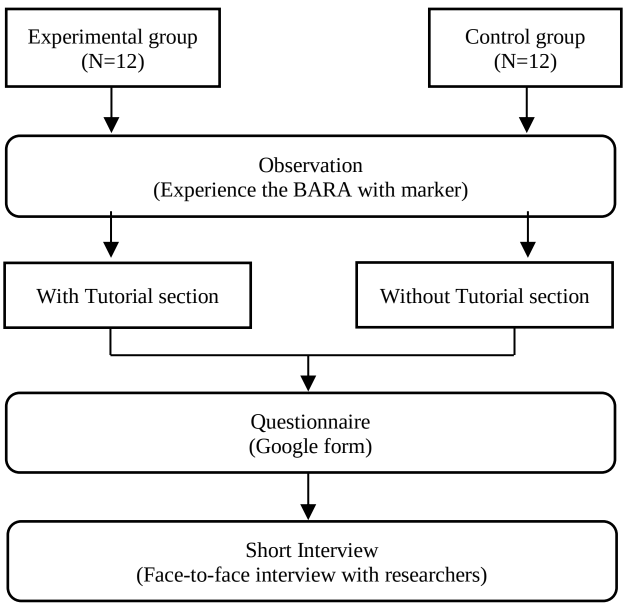


FIGURE 5. Procedure of The Experiment

Data Analysis

In this study, we conducted observation, questionnaire, and short interview with the participants. To understand further, two cameras were placed in front of the participants and at the side of the participants to videotape their expression, the tablet activities to get a clear view of the tablet display and their hand gestures while using the given MAR BARA. All the data from the videotaped were analyzed. We also observed the behavior/action of each of the participants while they experienced the apps since the researcher was in that room. However, the analysis of those video (expression and hand gestures) data was not covered in this paper. For the questionnaire, we designed the questionnaire following a 5-point Likert Scale (1-strongly disagree, 2-disagree, 3-neutral, 4-agree and 5-strongly agree) which the participants had to fill in via google form on the given link. There were multiple tasks the participants had to do and during that time, the camera recorded their action. Participants completion time was taken once they were done with all the tasks. The time taken was captured by researchers from the analysis of the video. The short interviews session was conducted to get feedback and the problem about the mobile application. During the brief interview sessions, all the answers from the participants were audio recorded. We analyzed the audio recorded by using Otter.ai software to get the precise transcriptions.

RESULT AND DISCUSSION

From this part of the experiment through questionnaire, the study focuses on the familiarity of the participants with the AR, their experience on using AR before, and their knowledge on how to use the AR, using the questionnaire. In the earlier part of the questionnaire, these are the questions that the participants need to answer:

(Q1) “I am very familiar with the Augmented Reality (AR)”,

(Q2) “I have used Augmented Reality (AR)”, and

(Q3) “I know how to use Augmented Reality (AR)”.

We categorized the findings into three themes which are familiarity, experience, and knowledge. The result of the questionnaire as shown in Figure 6. Both groups: control and experimental group, were asked the same questions for the earlier part of the questionnaire. First, for the familiarity, it was found that 5(42%) participants from control group and 6(50%) participants from experimental group were familiar with AR as shown in Figure 6. Then, for the experience, it was found that 4(33%) participants from control group and 5(42%) participants from experimental group state that they have used AR before, and lastly for the knowledge, it was found that 7(58%) participants from control group and 4(33%) participants from experimental group know how to use AR. Therefore, 11(46%) out of 24 participants were familiar with AR, 9(38%) out of 24 participants have used AR before this, and 11(46%) out of 24 participants claimed that they know how to use AR.

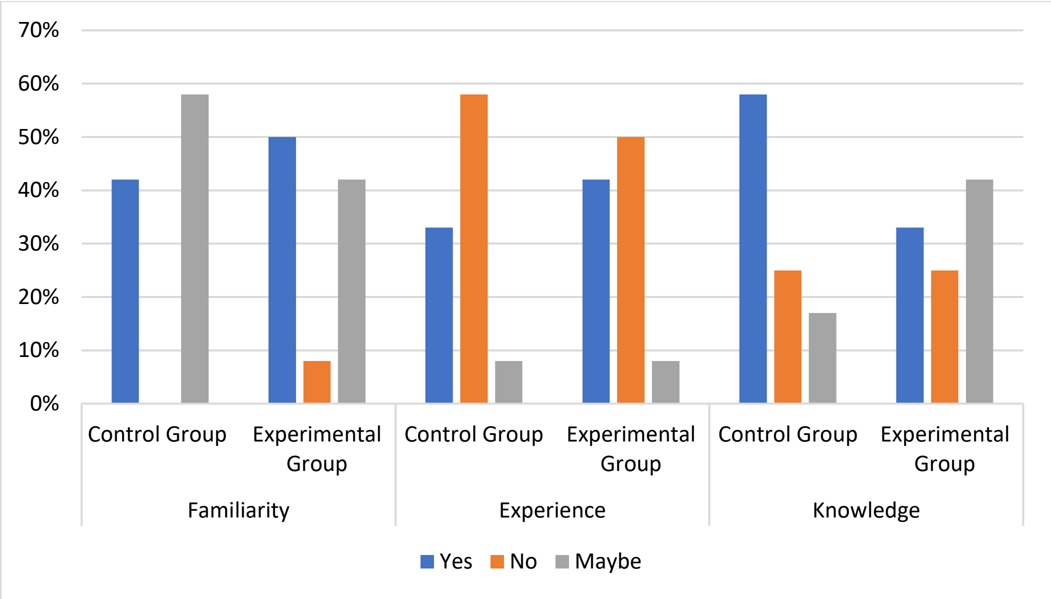


FIGURE 6. The results of questionnaire

In addition, the time taken was analyzed for each of the participants to complete the task based on observation. The start time was recorded when the participants started to grab the tablet and the end time was taken when they put the tablet on the table. The range of time taken for the control group was between 1.47 minutes and 8.07 minutes, while for the experimental group, the range of time taken was 4.29 minutes to 12.54 minutes. It was found that the participants in the experimental group take more time to complete all the tasks given compared to participants in the control group. For the experimental group, the participants were provided with a tutorial section by a virtual tutor explaining how to use the apps. Due to the duration of the virtual tutor in the tutorial section, the completion time for the experimental group was reduced by 1 minute. Figure 7 shows the graph of the time taken of the completed task for both groups.

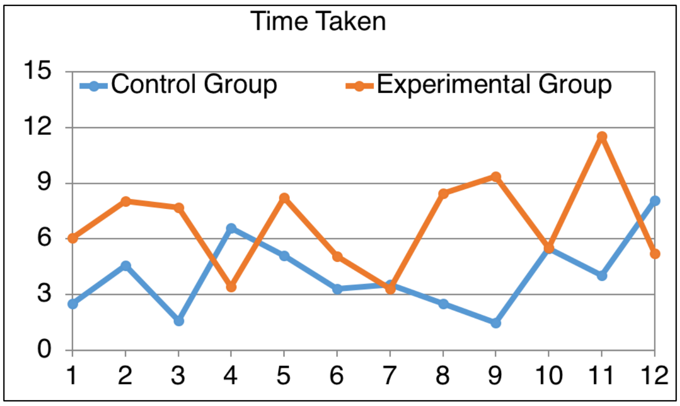


FIGURE 7. The Comparison of time taken complete the task

From the graph above, we conclude that the participants in the experimental group take more time to complete all the tasks given as they manage to open the AR function compared to the control group. This also happens because the participants were able to experience the AR function and they managed to utilize the 3D model of the brain anatomy in various parts of view. In the case of the AR interface, the scale of the environment may be the most crucial factor affecting task time, since users may travel more between targets, and movement may trigger more tracking issues (Jarkko & Takafumi 2018).

Furthermore, we analyzed the number of participants who managed to open the AR function from the recorded video while experiencing the apps. We divided it into three which are: yes (manage to open the AR), no (could not find where the AR), and black screen. The black screen occurs when the device camera is blocked by the table resulting from the participants' failure to grab the tablet from the table. This shows that the participants were not aware of how the AR camera functions. It was found that only 4(33%) participants from the control group and 11(92%) participants from the experimental group were successful at opening the AR scene as shown in Figure 8. This shows the relationship with the results from Figure 6, where 33% of the participants from the control group state that they have experienced AR before. However, 5(42%) participants from the control group faced a black screen because they did not hold the tablet and supposedly needed to use the back camera to detect the marker. Unfortunately, one participant from the experimental group did not manage to use the AR camera and faced the black screen problem because she misunderstood the instruction given. The participant used the front camera to scan the marker instead of using the back camera. Moreover, there were 3 participants from the control group that failed to find the AR function in the apps. Based on the observation, the participant faced difficulty following the researcher's task to explore the AR function in the application.

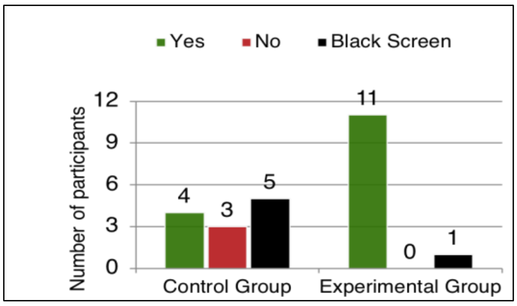


FIGURE 8. The number of participants successful to open the AR function

Next, the questionnaire related to the virtual tutor was only given to the experimental group. They used the BARA with the tutorial section that explains how to use the app. Table 4 shows the questions that we asked the participants about the virtual tutor.

TABLE 4. The sample of questions on virtual tutor

		Questions
Sample of questions asked to participants	*Q1*	*The virtual tutor used in the Brain Anatomy Revision Application (BARA) is very appropriate.*
	Q2	*The virtual tutor in the Brain Anatomy Revision Application (BARA) is very helpful*
	Q3	*The virtual tutor explains enough information on how to use the Brain Anatomy Revision Application (BARA).*
	Q4	*The information and instructions provided by the virtual tutor are very clear and understandable.*

Based on the first question that was asked, it stated that 1(8.3%) participant have a neutral reaction, 9(75%) participants have agreed, 2(16.7%) participants have strongly agreed that the virtual tutor used in the BARA is very appropriate. The following questions regarding whether the virtual tutor in the BARA is helpful or not, there were 1(8.3%) participant that had a neutral reaction, 7(58.3%) participants have agreed, 4(33.3%) participants have strongly agreed, as shown in Figure 9. For the third question, it stated that 2(16.7%) participants have a neutral reaction, 7(58.3%) participants have agreed, 3(25%) participants have strongly agreed that the virtual tutor explains enough information on how to use the BARA. The following questions are if the information and instructions provided by the virtual tutor was noticeably clear and understandable, 1(8.3%) participant had to disagree, and 1(8.3%) participant had a neutral reaction. In comparison, 7(58.3%) participants agreed, and another 3(25%) participants strongly agreed as shown in Figure 9. There was 1 participant who disagreed with the information and instructions provided by the virtual tutor and said that it was unclear and could not understand it. During the experiment, this shows in her action where she did not manage to open the AR function to interact with the 3D model.

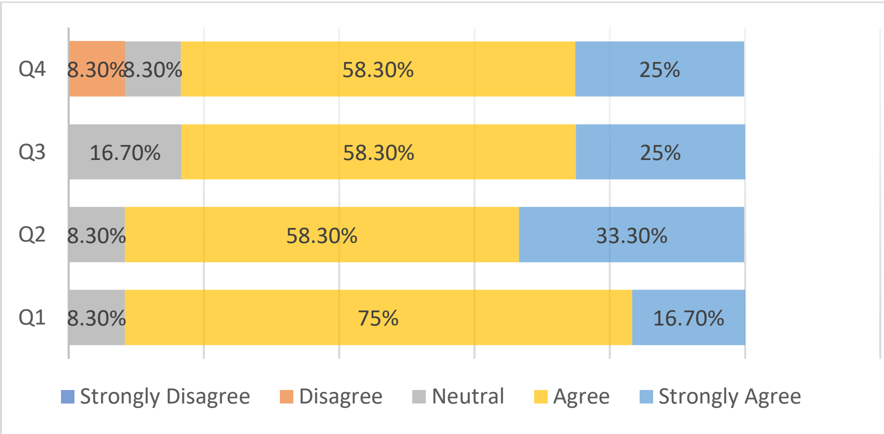


FIGURE 9. Analysis result on based on the sample questions on virtual tutor

Interview with Participants

The short interview was conducted to get feedback directly from the participant for further study purposes. The interview was around three to five minutes with 24 medical students. All the responses from the participants were audio-recorded. We analyzed the records by using Otter.ai software. During the interview sessions, participants expressed their opinions and suggestions regarding using BARA. In general, students felt BARA was interesting, convenient, full of information about brain anatomy, and interactive. They described several difficulties related to system design and usability. All the participants' answers were analyzed to extract the keywords. We point out all the problems facing the participants. The keywords were grouped into several categories which were 3D model or AR function, text, audio, 3D interaction and others, as shown in Figure 10. Each of the students mentioned more than one problem listed while they experienced the apps. Overall, there were 35 of the problems listed related to BARA.

Based on Figure 10, 39% of listed problems while experiencing the BARA came from the 3D model in AR or AR function, followed by 22% of it due to the audio, the text and 3D interaction were simultaneously 14%, and the rest of 11% was from other issues. We could clearly say the most common issues mentioned by the participants are: "*I don't know how to apply the AR*" from the 3D model or AR function category, and "*The audio of the narrator keeps on repeating explaining the notes*" from the audio category. In the text category, they complained that some fonts were small, and others were large, and that the text could not be zoomed. Furthermore, participants said "Can't rotate it diagonally wise" for 3D interaction, which means they can't interact with the 3D object by rotating it diagonally and they also stated that they were unable to zoom the 3D object. For the other concerns, it was difficult to manage the marker and the tablet at the same time.

Each of the feedback would be the references for the development of the MAR application in the future. We will also make some improvements based on the student's suggestions. For example, the narrator's voice will be set to explain the notes just once, and the user will need to click the button to hear it again. The font of the app will be designed to be consistent from beginning to end. In addition, we will include instructions on how the user should interact with the 3D object, such as zooming and rotating.

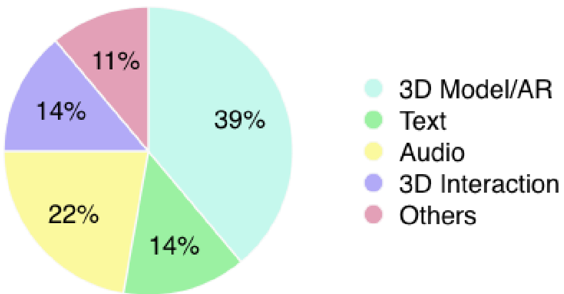


FIGURE 10. Categories of the listed problem by participant related to BARA

CONCLUSION

In this paper, we present a virtual tutor in the tutorial part, named Otus, which assists the students on how to use a MAR application, named the BARA (Brain Anatomy Revision Application) as a guidance for students to experience the AR. We conducted an experiment by dividing participants into two groups: control group and experimental group. From the investigation, the control group spent less time compared to the experimental group when exploring the application as they did not manage to interact with the AR function and explore the 3D model in it. This may be because the participants did not hold the tablet. The tablet then showed the black screen, and the participants were clueless on the steps needed in opening the AR function. At the same time, the experimental group spent more time completing the task because they managed to open the AR function and explore the 3D object in the app. We concluded that the tutorial explanation by the virtual tutor that we put at the beginning of the application manages to help students better understand how to use the application itself. For the participants who were using a front camera instead of a back camera and could not find where to click to view in AR, we suggested to the user a smartphone holder as a solution. However, we also concluded this is an interesting finding, as we will need to design a virtual button to further minimize this type of mistake.

From the finding of this study, we will modify and re-do BARA with Otus the assistant, accordingly. Each problem commented by the participants will be analyzed and listed in the next phase of modifications. Furthermore, we also will expand the work on verification and on the elements covered in the tutorial section by Otus, that are agreeable to the participants. The changes will cover in terms of the font that we use, the explanation that we provide, and the image clarity and sharpness. To further understand users' requirements for the assistance, these are our plans:

1. Focus on how to deliver the guidelines for users on how to use the AR
2. Check on the instructions in the tutorial section whether users clearly understand the information.
3. The use of computer science terminology might hinder app use adoption, due to users being not very familiar with such terms, an immediate example being the users from a medical background in the tests above.

This study has several limitations. First, the participants in this study were not evenly distributed in terms of their expertise in AR technology. There were some participants who had experience with AR technology before this. Second, the sample size for each group in the research was modest. We were unable to conduct a correlation test to reach the best conclusion. We plan to conduct our future study to address these limitations.

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