User Preferences on Supplementary Learning Tool in Physics Experiment Using Mobile AR

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ABSTRACT: Mobile augmented reality (AR) technology is utilized as the medium for enhancing real time interaction between user and technology by adding virtual contents to the real world. However, this technology is about to grow in the learning landscape. The focus of this article is to determine user preferences on technology based supplementary learning tool in Physics experiment. In this study, a user requirement is conducted by means of questionnaire. This questionnaire was distributed among target group and school teachers. Findings of user requirements provide evidence on the necessity and potentials of Mobile AR to be used as a supplementary learning tool. This exercise provides details on the learning content and technology they would like to acquire.

INTRODUCTION

Learning is always associated with location and time. Mobile AR provides the flexibility and mobility of learning beyond time and location. Science, Physics, Chemistry, and Biology subjects require authentic activities such as experiments to understand the concept in depth and correct. Physics may comprise of complicated facts that involve non-living things. By conducting real experiments most of the Physics' concept of non-living things only could be proofed and critically understood its complexity (Ibáñez, Di-Serio, Villarán-Molina & Delgado-Kloos, 2016; Akcayir, Akcayir, Pektas & Ocak, 2016). Furthermore, literature revealed that the priority has been given for inside and outside of the classroom learning instead of the experiments (Cheng & Tsai, 2013). The science experiments were overlooked because of time constraint and lack of equipment. Besides, there are several experiments which are risky to conduct in a school laboratory. Hands-on experiments, observation, exploration and discovery are the ways to feel and understand the magic and the logic behind the science concept (Ekanem, Ekanem, Ejue, & Amimi, 2010).

Therefore, this paper focuses on the design and development of a mobile application called using Augmented Reality in Physics Experiment (MARPEX). In this study, user requirements conducted through distributing questionnaire. This questionnaire was distributed among target group and school teachers. Findings of user requirements provide evidence on the necessity and potentials of Mobile AR to be used as a supplementary learning tool. This exercise provides details on the learning content and technology they would like to acquire. The following section discusses the user requirements conducted before the design and development of MARPEX in order to know students and teachers' expectations for an effective technology based learning landscape.

MOBILE AR IN SCIENCE LABORATORIES

The development of Mobile AR has grown remarkably. Most of the studies from the year 2010 till 2016 still developing computer and

webcam based application platform for learning for various types of learning namely, game-based learning, e-learning and courseware.

There are few numbers of AR projects emphasized handheld devices (mobile device and tablet). Akcayir et al., (2016) designed a mobile-based augmented reality to evaluate the effectiveness of the use of mobile-based augmented reality in science laboratories. The result shows that the implementation of technology in learning positively influences the students' laboratory skills and could witness the tools they expected in a real laboratory setting. Ibáñez, Di Serio, Villarán & Kloos (2014) developed an AR-based simulation system (AR-SaBEr) utilizing computer and webcam devices for the learning of basic principles of electricity. The purpose of this study was to assess to which extent an AR learning application affects the students' level of enjoyment and learning impact. The analysis indicated that the augmented reality application led participants to reach higher flow experience levels than those achieved by users of the web-based application. Then Ibanez et al., (2016) investigated how supporting the student focus on meaningful activities affects behavior and learning performance. The findings revealed that AR-based simulation system showed better learning achievements than students' in conventional learning method. Moreover, Li, Gu, Chang and Duh (2011) determine how an AR-based simulation influence learning the effectiveness among university students. The results depict that AR-based collaborative learning highly influenced the students in term of skill development, self-reported learning, and learning interest (Li et al., 2011).

Besides that, there are plenty of applications in Play Store for Physics concept learning, Physics formula, and experiment. All the existing application illustrates the Physics concept using gamification technique using 2D or 3D model. Existing Mobile AR applications for Physics provide plenty of features like zoom in and zoom out, take apart (break the apparatus parts apart and reassemble), label, highlight and hide the touched part, snap the image and glassy view. All these features are definitely attracting user's attention but the effectiveness of the features in academic is still untouched.

CONSTRUCTIVISM IN ACTION

Learning from the real environment enhances the students' confidence in their own skill. These circumstances influence students' learning motivation (Prawat & Flowden, 1994; Von Glasersfeld, 1989). Constructivism occurs as learners are actively involved in a process of knowledge construction from their previous knowledge (Fosnot, 2013). Constructivism makes sure that students are actively participating in academic activities such as experiments, real-world problem solving, observation and discussion for an in-depth knowledge (Wojciechowski & Cellary, 2013; Agommuoh & Ifeanacho, 2013). Constructivism in a learning domain is more on how to think, understand and transfer knowledge to another (Wojciechowski & Cellary, 2013; Fosnot, 2013). The constraint on constructing their own learning experience hinders them to continuously engage in learning, especially for the digital natives or Apps generation. Constructivism permits active participation in Physics learning (Wojciechowski & Cellary, 2013). AR Physics laboratory experiment provides the experience of discovery, exploration, 3D visualization and collaboration with the simulated learning environment.

USER REQUIREMENTS ANALYSIS

The initial investigation conducted in order to get the preferences from teachers whom teaching Physics and students. Hence, in this study, we conducted a user requirement analysis among teachers to determine their expectations and suggestions for an enhanced learning landscape using Mobile AR. We set up an online form for (i) respective teachers and (ii) school students undertaking Physics. These forms include questions on their limitation in conventional teaching material and their expectations from a supplementary learning tool. Links to either one of the forms are sent accordingly to dedicated groups of respondents. A snowball sampling method implemented to identify the respondents. A purposive sampling

method utilized to obtain respondents from school students.

RESULTS AND DISCUSSIONS

TEACHER PERSPECTIVES

The respondents are five teachers who have experience of teaching Physics for more than 10 years. Among the respondents four (80%) are female and one (20%) in male. Table 1 illustrates the summary of respondents (teachers) demographic data.

Table 1. Summary of Respondents (Teacher) Demographic Data

Respondent Profile		Frequency	Percentage (%)
Gender			
1.	Male	1	20
2.	Female	4	80
Experience of teaching Physics			
3.	10 -12 years of teaching experience	5	100
Requirement for supplementary learning tool for Physics			
4.	Yes	5	100
5.	No	0	0
Do you prefer to have technology based supplementary learning tool for Physics?			
6.	Yes	5	100
7.	No	0	0
Have you heard about Augmented Reality technology?			
8.	Yes	0	0
9.	No	5	100
Do you prefer the AR application as main apparatus to assist Physics laboratory experiments?			
10.	Yes	4	80
11.	No	1	20
Do you agree that Electromagnetism is the difficult topic to simulate in a laboratory experiment?			
12.	Yes	4	80
13.	No	1	20

Based on Table 1, respondents have more than 10 to 12 years of teaching experience in Physics subject. They unanimously agreed that a supplementary learning tool is very much required in Physics to aid students. Based on their feedback, the teachers are looking for a technology-based learning tool and surprisingly, they are not aware of Mobile AR in the education domain. 80 % of them agreed that it is difficult to simulate experimentally from electromagnetism topic. This is due to their lack of ability to visualize the abstract content. Other than that, 20% of them agreed that lack of motivation among students and lack of fully equipped school laboratory cause the constraints of the teaching and learning process in a Physics experiment. The teachers suggested that the learning tool should comprise of animated three-dimensional models, simulation of apparatus and material related to experiments and support to understand the theoretical concept of Physics experiments.

STUDENT PERSPECTIVES

The user requirement analysis for students conducted in a secondary school in Perak. It is a must for researchers to seek permission and approval from the Ministry of Education before conducting any research in schools. Thus, first of all, we formally applied for the permission from the Education Policy Planning and Research Division (EPRD). Then, we applied for the permission from Perak State Education Department attached with EPRD permission letter. Consequently, we met the school headmaster with these permission letters and explained about the research study and the purpose of this study. Then, we discussed with the science teachers, as they are the content experts to discuss about the content. After their approval, the link to online form is circulated among the students. In total, twenty-two students from upper secondary from Physics classes participated in this investigation.Table 2 depicts the summary of respondent's feedback.

Table 2. Summary of Respondents (Student) feedback

Respondent Profile		Frequency	Percentage (%)
Gender			
1.	Male	12	55
2.	Female	10	45
Age			
3.	16	15	68

4.	17	7	32
Experience of Physics subject			
3.	Tough	3	14
4.	Moderate	14	64
5.	Easy	5	22
Requirement for supplementary learning tool for Physics			
4.	Yes	22	100
5.	No	0	0
Do you prefer to have technology based supplementary learning tool for Physics?			
6.	Yes	5	100
7.	No	0	0
Have you heard about Augmented Reality technology?			
8.	Yes	16	70
9.	No	7	30
Do you prefer the AR application as main apparatus to assist Physics laboratory experiments?			
10.	Yes	20	90
11.	No	2	10
What kind of learning method you prefer for Physics?			
12.	In classroom learning	11	45
13.	In Laboratory experiments	13	54
Which device you prefer for a laboratory experiment learning environment			
14.	Computer/ Desktop	10	45
15.	Mobile / Tablet	12	55

Based on students' feedback whose within the age of 16 to17 years old, it is found that for them, Physics is not easy, but it is not tough either. Among the respondents, 64 % of them agreed that Physics is a moderate subject for them and it could be easy and become a favorite topic if they are able to visualize the abstract part of it. It is clear that students are interested in electromagnetism topic due to its interesting facts, logic, and factual nature, cultivate creativity, relevance to daily life phenomena and the ability to visualize non-living things. Unfortunately, the limitations on apparatus for such experiments limit student's achievement in that particular topic.

Besides that, 54 % of the respondents prefer to have experiments rather than a conceptual learning in a classroom. This enables them to fully concentrate and observe the in depth details of the experiment. Other than that, according to students the experimental activity is fun, interesting, easy to learn the content and process enhance their communication skills, and an opportunity to witness how the phenomenon happens. Apart from that, 55% of the respondents preferred handheld devices like smartphone and tablet for this kind of learning due to its mobility and lightweight with wide screen. Moreover, all respondents prefer to have Mobile AR as the alternative apparatus for experiment with animated 3D objects as the information representation rather than solely dependent on school textbook, teachers' knowledge, and online sources. Hence, Mobile AR in a Physics experiment with the addition of animated three-dimensional models is proposed as supplementary learning tool.

CONCLUSION

This paper outlines user requirements from both teachers and students for supplementary learning tool for Physics using Mobile AR. An active participation and 3D representation provide deeper understanding and the obtained knowledge retains longer than usual. The experience of doing hands-on experiment encourages students to explore and discover. It is anticipated that by allowing students manipulating virtual learning content on top of the real environment, they will gain this hands-on experience. The future of this research is to focus on designing and developing Mobile AR for Physics Experiment (MARPEX) application based on the feedback and the user requirements. The expert review and pilot study will be conducted to determine the interface functionality and usability defects. The user evaluation will then be conducted to determine the impact of Mobile AR in Physics Experiment. Moreover, it is anticipated that this innovation in the learning process is able to enhance students' motivation to pursue science-related higher education and professions.

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