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A Framework for Developing Mobile-Augmented Reality in Higher Learning Education

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Abstract

Objectives: Mobile learning has contributed effectively at various Universities in Malaysia since its implementation. Mobile Learning is defined as use of mobile or wireless device for learning purpose while giving mobility. **Methods/Statistical Analysis:** Mobile learning concept starts from e-learning that slowly develops into mobile learning as technology improved over the decades. Augmented reality or well-known as AR combines real environment with virtual object that users can interact with, with mobile device such as smart phone and tablet that are powerful enough to support augmented reality, mobile-Augmented Reality is possible to be used in education. **Findings:** Using mobile-Augmented Reality in education can help gain interest from students during learning session. The current problem with mobile learning is the visualization and content presented in the application, where it may not be appealing for student to use because it is mostly text based. Next issue regarding mobile learning is the user interface where it may not be usable to a non-experience user and most important is the framework available for mobile-Augmented Reality is still limited. **Application/Improvements:** The aim of this paper is to propose a framework for developing a mobile-Augmented Reality in Higher Learning Education adapted from several framework proposed by previous researchers to support development of a mobile-Augmented Reality application for Network Fundamental courses offered by public Universities in Malaysia. Thus, increase the student motivation towards learning with AR.

Keywords: Education, Framework, Higher Learning, Mobile Augmented Reality

1. Introduction

This study aims to explore the problems of mobile learning at the institute of higher learning in Malaysia. There are several benefit of utilizing mobile-Augmented Reality (mAR) as a medium for learning, Barreh et al.[1] stated that Augmented Reality (AR) helps enhance the learning experience by using 3D synthetic object for students to view the object using their eyesight with various mobile interfaces; the 3D object are able to be manipulated through interaction. This allows the student to visualize the learning material more clearly with the help of 3D object and interaction to view how certain object would react. According to Nincarean et al.[2], student can use smartphone and tablet to interact with AR object, this allows student to use AR with device that they may already have, which allows them to install the application and use it virtually anywhere. Problems that arises that researchers found about education are difficulties in visualizing the learning material, current mobile learning user interface are complicated and limited framework for developing[3–5]. Mobile learning development were motivated by the researchers due to the problems student faced while learning which is trying to understand what they are learning. Zarwina et al.[3] discovered that current mobile learning application lacks interactivity between the student and the device in terms of learning which is the main causes that factor into student unable to focus what they have learned and make it less memorable. User interface plays an important role in an application; it can determine the level of usability of the application. Corbeil et al.[4] stated non-technical student may have disadvantage in using the application as it required them an additional learning curve, this means that different people have different set of skills; a good user

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interface should allow both technical and non-technical students to use the application with little to no guidance. Another problem that arises is framework, framework is used to develop a mobile application to ensure that the application achieve what it has set to achieved. Framework can also be used as a standard so that an application may feel familiar when using thus eliminating the need to learn navigating a user interface. Framework for mAR is still lacking in terms of development, having a framework is important especially for developer to develop an effective mobile learning application[5] while gaps identified[6] in mobile learning is that there is no pedagogical theory in designing a mobile learning application.

AR combines the real world with virtual object through smart phones and markers. AR is more accessible nowadays with better and faster Smartphone as well as affordable prices. The use of AR used to be limited for computer and laptop, but current Smartphone are capable enough to handle the processing power. AR can increase the students attention towards the learning material, exercise was developed to increase the student understanding on the subject[7]. The term 'AR' simply describes a combined technology that work together to allow computer-generated content to mix with real environment also known as mixed reality that is produce through the display. AR also encourage students be more active during the learning process through the interactivity of its applications[8]. Thus, it enables students to think both critically and creatively that can further improve their learning experiences and understanding. Nowadays, AR shows great potential in terms of technology with its visualization capabilities. AR technology can make an impact especially on education[9]. Similar to E-Learning, collaboration between learners and instructor can be enhance through mobile learning and further improve the interaction amongst each[10]. The advantages of AR in education can help by integrating teaching and learning for subject that is difficult to explain[11], AR can be used to visualize a concept to student to further understand. However, through meta-analysis conducted by researchers in the present study, result shows that studies on AR in education field are still lacking. The use of mobile technology may disrupt the field of education stated Martin et al.[9], however, mAR has the most potential when it comes to emerging technology to be widely used-claimed Martin et al.[9]. The advantage that mobile device has over desktop PC is portability[12], where user can take their mobile devices anywhere they go. Student visualization skills are further enhance through AR, this is proven by the statement of Furht[13] which claims that AR is a visualization tool powerful enough to be used for exploring real world structures along with additional contextual information. Future researchers are suggested to improve the Internet portability[8], which can enable user to access their system and have updated content whenever and wherever they use it. As a contribution, to help enhance the student experience, AR is one of the appropriate ways to deliver information to students through visualization.

2. Mobile-Augmented Reality (mAR) History, Interface and Framework

Table 1 shows the evolution of AR development towards mAR including its founder, application built for and the equipment equipment used by the founder leading to the year 2008 starting from 1962. The table shows how that from 1962-1994, various equipment such as Computer, HMD and display were used to view virtual content, this equipment does not provide mobility thus could not be used outside. It was not until the year 2000 where the University of Australia developed AR Quake that has mobility and allow user to play the application indoor and outdoor. In the year 2008, Wikitude developed Wikitude Drive which is the first application for mAR that utilizes a handheld device; it was used to guide drivers to a specific location using their mobile device. The history of AR shows that the equipment being used for AR application becomes smaller decade after decade, having smaller equipment makes it possible for user to use the application in more places that was not possible before.

Mobile device such as smartphone and tablet enables allows people to use it for communication, entertainment, work, accessing the Internet to gain information as well as learn through instruction. mAR has been made possible with the rapid development and increase usage of mobile devices as stated by Nincarean et al.[11]. This allows more users to experience AR by using their mobile device such as smartphone or tablets through an application that can be easily installed. mAR is said to replace display technology such as Head Mounting Device (HMD), binoculars and helmets with AR research rapidly emerging that include the uses of GPS tracking, user studies, visualization, and collaborative application[14]. Mobile device is the most widely used technology as it can be found in

Table 1. Evolution of AR development

Year	Founder	Application	Equipment
1962	Morton Heilig	Sensorama – motorcycle simulator with multi-sensory technology	Display
1968	Ivan Sutherland	The Sword of Damocles Head Mounting Display (HMD) – First Virtual Reality (VR) device	Head Mounting Device (HMD)
1985	VIDEOPLACE	Allow user to interact with virtual object in real time.	Display
1992	Tom Caudell and David Mizell	Software that assist Boeing in manufacturing and engineering process.	Computer
1994	Paul Milgram and Fumio Kishino	Virtual Environment – Immerse user to virtual environment using Virtual Reality (VR).	Projective
2000	University of South Australia	AR Quake –mobilizing the application allowing user to play indoor and outdoor.	Tracking
2008	Wikitude	Wikitude Drive – first mAR application for smartphone, direct drivers to location using mobile device.	Handheld

industries such as advertising, construction, education, entertainment[15].

Combination of virtual and reality methods can increase the understanding in learning[14]. mAR has been used in education and other industries such as advertising, entertainment and tourism. Using AR, user will be able to experience virtual environment surrounding them with added digital objects such as videos, audios, images, and touch interaction. With mAR, HMD can be replaced. Before designing the mAR framework[14], previous research comparison with various industries that utilizes mAR includes advertising, entertainment and tourism. Table 2 shows the different types of mAR interface that is used through out different industries such as advertising, education, entertainment and tourism. Each interface has different uses in different type of industries may use specific interface for its requirement.

Table 2. Explanation of different types of mAR interface[14]

Types of mAR Interface	Explanation
Tangible Interface	Support direct interaction with real equipment, physical objects and tools
Collaborative Interface	Multiple display support co-located and remote activities. Co-located enhance display and improves physical collaboration using 3D interfaces.
Hybrid Interface	User focus on specific physical objects to be displayed on screen.
Multimodal Interface	**Merges real object and system using speech, touch, natural hand gestures and gaze.**

Table 3 shows that the used of interface in education is still lacking when compared to other industries. Meanwhile only Tangible and Collaborative interfaces are implementing in education where Hybrid and Multimodal interface has yet been implemented. In advertising, it is found that through Multimodal, customer can interact with the application thus increasing the usability of the application. Hybrid and Multimodal can boost the motivation and learning outcome of the students if it were to be implemented in Education according to Jamali et al.[14].

Table 3. Interface used in different industries

Current mAR	Types of mAR interface							
Application	Tangible		Collaborative		Hybrid		Multimodal	
Dimension	2D	3D	2D	3D	2D	3D	2D	3D
Education	√	√	√	√	x	x	x	x
Advertisement *Interactive product evaluation	√	√	√	√	√	√	*√	*√
Entertainment	√	√	x	x	x	x	x	x
Tourism	√	√	x	x	√	x	x	x

Mobile learning has potential in education especially higher education where it is view as appropriate to integrate mobile learning with students because most students have access to a mobile device. For example, universities such as Stanford, Abilene Christian, and the University of Washington, have utilized and pioneering mobile learning to further assists its student[16]. Some of the challenge

of mobile learning includes social, cultural, and organizational factors[14,17]. Before implementing mobile learning on college campuses or University, it is important to understand the perception of that particular University or college to ensure that they accept or allow their student to use mobile learning as a medium for learning.

Mobile learning is gaining popularity because it offers flexibility and comfortable usage to student and educator to use on a daily basis. Mobile learning has been implemented in various universities across the globe to deliver learning material to students anywhere and anytime in multiple methods. The effects of mobile technologies usage in learning and teaching are highlighted by Gikas et al.[18] through social media in the form of Skype, Twitter, and Blogs for providing students with better learning. Students that use mobile devices and E-Book help students in getting familiar with digital library thus raising the student usage of mobile device addressed by Glackin et al.[19].

Mobile learning requires both the learner and educator to work together for mobile learning to truly work as an educational tool. Having both the students the learner and educator the faculty member can help the focus of this study and to learn how mobile learning can help in educating the learner and help the educator to deliver the learning material better and more effective. A framework from Engestrom's expansive activity model to theorize mobile learning that was adopted from learning process occurring outside of a classroom proposed by Yousafzai et al.[20]. The framework consists of educator, actors and communication technology. Educators are controlled where as actors and communication technology is used to drive the technology in mobile learning. The following are existing application of AR used in Universities. Table 4 shows the current available mAR application used in higher learning education in different fields and for specific application.

Mobile learning (M-learning) has come to people attention because mobile devices are portable, ubiquitous, and easily accessible and used by many people. This situation shows that there is great potential to enhance learning with mobile devices.

M-learning is a trending research that many researchers are eager to explore more about the technology, learn how it affect students and educators, and develop an infrastructure require to built by developers. M-learning aims to utilize mobile technologies to maximize its uses in higher education institutions and achieve the educational mission simultaneously. Mobility dimensions can be defined as mobility of technology, learners, educators and learning. M-learning is an evolution of e-learning that uses mobile technology to enable students to learn outside of the classroom[21].

Table 4. Mobile learning application in higher learning education

Source	Field/ Universities	Application
Jamali et al. (2014)	Medical	Human Anatomy HuMAR – Human Anatomy in Mobile Augmented Reality. Use multimodal interface for better interaction using 3D objects.
Nazatul et al. (2014)	Computer Science	Computer Organization Microprocessor – chapter in Computer Organization and Architecture, identify student perception using AR technology
Coimbra et al. (2015)	Polytechnic Institute of Leira (Portugal)	Mathematics Mathematical Analysis – Enable student to understand concept through interaction and visualization.
Wendeson et al. (2010)	Computer Science	Structural Programming Windows Mobile Platform – Tools includes lecture materials, assignment, academic information, discussion and quizzes.

The rapid development of device involving mobile computing and Internet capabilities has change the nature of higher education[22]. A survey by the Educause Center for Applied Research (ECAR)[22] shows that the usage of mobile technology devices in classrooms is leading in higher educational environment by students. Mobile technology is essential in contributing to student academic achievement and activities claimed 67% of

students in the survey by ECAR. With mobile technology, higher education institution integrated with mobile technology provides opportunities and challenges to both academicians and students[18]. Theory of Constructive Learning a process where learners collect their present and past knowledge to build a new idea or concepts[23].

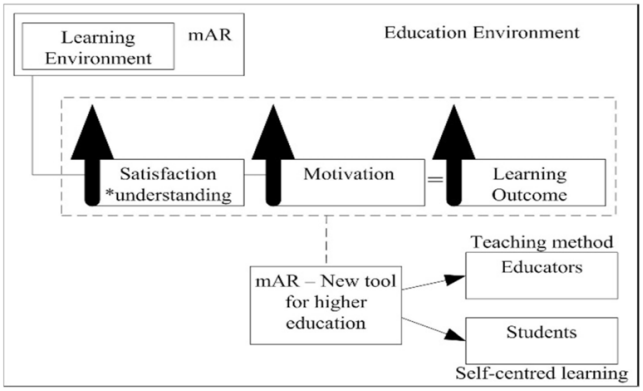

Figure 1. mAR framework for education[14].

Figure 1 shows the mAR framework[14] for education. The framework is a combination of several interfaces that includes multimodal and hybrid that aims to benefit and support student-centered learning through mAR as a learning tool that assist students. Multimodal interfaces enable students to click and interact with the application at their own pace. Multimedia elements allow people receive and understand the message through visualization that can improve memorization of an object and student motivation in learning. Other than that, mAR also benefit the educator in explaining more complex objects to student. Table 5 shows framework used to develop a mobile learning application highlighting its elements and objectives.

3. Material and Methods

The mAR framework[14] adapted was used in this research. For the contents of the application that will be developing is Network Fundamental course. Thus, the proposed framework will name as Net mAR framework, which aims to assists students who are taking computer science course learn networking device through multimodal interface with 3D object interaction, image, video and voice. By using the multimodal interface, it motivates the students in learning as well as helping them retain the information longer[14]. The application then will be developed using software tools such as Unity 3D SDK, Vuforia and Blender, smartphone and tablets will be used to test the application during pilot testing to ensure all bugs and error are fixed before deploying in data collection. During data collection, the application will be given to students in several chosen Malaysia universities, where 30 students from each university will randomly select to use the application and get their feedback through the questionnaire given. The following figure shows the flow of the methodology used to develop the Net mAR framework.

In phase 1, the conceptual features to be applied on the application for Net mAR framework will be identified, for this research, the multimodal interface will be used as the primary interface of the application. The multimodal interface has multiple inputs that the user can use to navigate with the application; this includes 3D object, videos, image, voice and interaction. Multimodal interface provided positive response from users based on[14] researches. Other than it can also increase the student motivation to learn as well as enabling them to understand better and longer retention of the information.

Phase 2 focuses more on the software and hardware requirement to develop the application. The software that will be used in the research is Unity 3D SDK, Vuforia and

Table 5. Framework comparison of mobile learning, lifelong learning and mAR

Framework	Elements	Objectives
Mobile Learning by Liu et al. (2008)	Requirement and constraint analysis, Mobile learning scenario, Technology, environment design, Learner support services design	Find common features of mobile learning for potential and existing user to increase motivation and expectations.
Lifelong Learning by Norazah et al. (2014)	Theories of learning, Generic mobile environment, Mobile learning context, Learning experience and objective	Achieve user goals, Measure enjoyment, user satisfaction and motivation
Mobile-Augmented Reality (mAR) by Jamali et al. (2014)	Tangible, Collaborative, Hybrid, Multimodal	Using Hybrid and Multimodal to improve object memorization and student motivation through visualization. Helps educator in explaining complex objects.

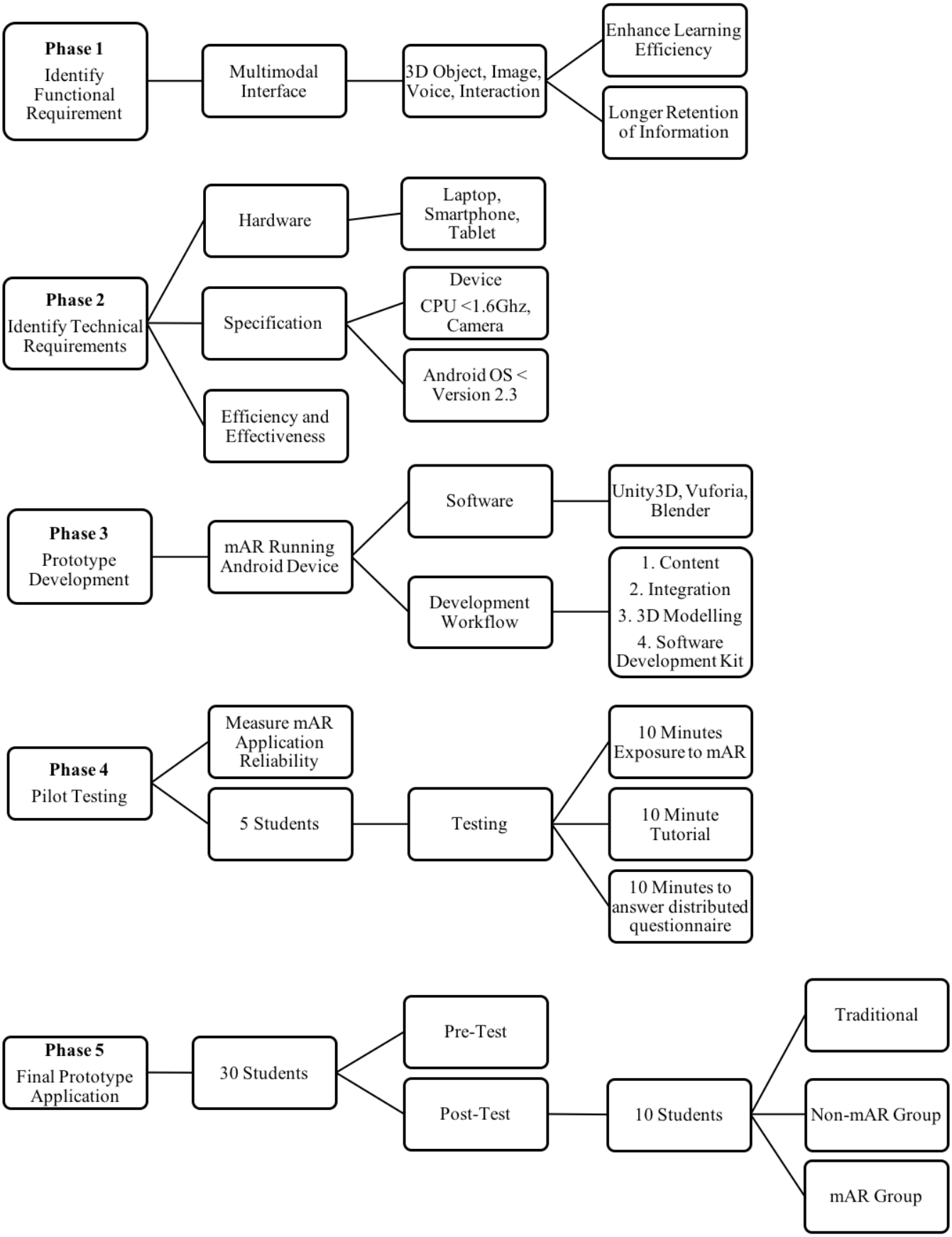

Figure 2. Flow of methodology for net mAR framework.

Blender based on previous studies on mAR application[14]. Unity 3D SDK is used to build the user interface of the application as well as importing 3D images and designing the whole navigation interface to allow better usability towards students. Vuforia will be used to store the data of 3D object in a marker, a marker can be an image or a generated image similar to QR Code, by using a camera to scan it, the 3D object and related information can be shown on the display. Blender is used for modelling 3D object, by using a 2D image or schematic to trace and design into a 3D object.

The hardware for developing the application are Laptop running Windows 8 OS and above or Mac OS X 10.10 and above. Smartphone and tablet running Android OS 2.3 and above will be used to test the application to find any errors or bugs to fix and to further improve the usability of the application in the fourth phase.

Phase 3 will be prototype development, which will begin after gathering all the required hardware and software; the content used on the application was retrieve from an instructor at UMS for Network Fundamental who provided the PowerPoint slide. The type of device found on the slide such as router, switch and hub will then be used as a reference for the 3D models. The 3D models are then designed by using Blender software; the 3D model will then be imported into Unity 3D SDK to place the 3D object on top of the marker when used in the application. Additional information such as image, video, voice and interaction will then be added. Testing will then proceed in the next phase.

In phase 4, the reliability of the application will be tested through pilot testing where 5 students will test the prototype to find any errors or bug after being exposed to mAR and tutorial, they will then answer a questionnaire regarding the application to add additional features if required.

Phase 5 will begin after ensuring the application is ready to be deploying to student after debugging and fixing errors exists. The data collection phase will take place in four proposed Universities in Malaysia, which includes Universiti Malaysia Sabah (UMS), Universiti Pertahanan Nasional Malaysia (UPNM), Universiti Teknologi Malaysia (UiTM), and Universiti Teknikal Malaysia Melaka (UTeM), where 120 students collectively will be involved in the data collection process. 30 undergraduate students from each University who are taking Network Fundamental course in computer science program will be chosen to take part in the pre-test and post-test evaluation.

In the pre-test process, students will have to answer questions given without any learning material. However in the post-test, students will be split into three groups of 10 each from 30; the first group will be using traditional method (books or pdf/ PowerPoint notes), second group will use a smart device but without mAR, and third group will also use smart device, but with the use of mAR, they will then fill in the questionnaire distributed to get their feedback.

From the feedback received, the data will be analyzed using AMOS statistical software where PLS, SEM and CFA will be used to determine the usability of the application and the reliability of the framework formed from the research.

4. Conclusion

As a conclusion, mAR has a lot of potential to increase the student motivation towards learning with AR. A framework is important when it comes to developing mobile applications especially mAR, without a framework, the application would most likely, will not perform according to standards. In addition, user interface also be a factor in ensuring that the application will be usable to students. It is a hope that a framework for developing a mobile learning with AR can help the development of courses offered by Higher Learning Education, especially for public Universities in Malaysia more efficiently used.

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