THE EFFECT OF AUGMENTED REALITY COURSEWARE TOWARDS THE STUDENTS' 3D MODELLING PERFORMANCE AT A COMMUNITY COLLEGE

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UNIVERSITI PENDIDIKAN SULTAN IDRIS

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ABSTRACT

The purpose of this research was to determine the effect of an augmented reality courseware (ARC-3DM) towards the students' 3D modelling performance at a community college. This 3D Augmented Reality Courseware was developed using ADDIE model. The main research design used in this study to determine the effect of the courseware was a quasi-experiment with pre- and post-tests. The instruments used in this study consisted of pre- and post-tests and a set questionnaire to measure the users' perception on the usability of the courseware. The sample of the study consisted of 54 students randomly assigned into a control group (n=27) and a treatment group (n=27). Pre- and post-tests were conducted to both groups. System Usability Scale (SUS) questionnaire was administered to the treatment group in order to determine the perceived usability of the ARC-3DM courseware after the treatment. Descriptive and inferential statistics such as percentage, mean, standard deviation, and ANCOVA were used to analyse the empirical data. The analysis of covariance (ANCOVA), with the pre-test scores being the covariates, were conducted at the $\alpha = 0.05$ level of significance. The key result of ANCOVA [$F(1, 51) = 133.91$; $p < 0.05$] showed that the post-test of the treatment group (M=70.69; SD=17.25) was significantly higher than the post-test of the control group (M=53.48; SD=16.55). This indicated that after the four-week treatment, the experimental group has achieved higher performance in 3D modelling as compared to the control group. In addition, based on the SUS questionnaire, the majority (85%) of the respondents agreed that the ARC-3DM was helpful and user-friendly in improving their 3D modelling skills. In conclusion, the ARC-3DM courseware was found to be effective and useful in improving the users' 3D modelling competence. The implication of this research findings suggest that integrating augmented reality technology into the learning environment could optimize the learning experience and can enhance the students' 3D modelling skills. This courseware could be used as a novel learning tool to assist students in learning 3D modelling more effectively.

Keywords: Augmented reality courseware, 3D modelling performance, Effectiveness and usability.

KESAN PERISIAN AUGMENTED REALITY TERHADAP PRESTASI PEMODELAN 3D PELAJAR DI KOLEJ KOMUNITI

ABSTRAK

Kajian ini bertujuan untuk menentukan kesan perisian augmented reality (ARC-3DM) terhadap prestasi pemodelan 3D pelajar di kolej komuniti. Perisian augmented reality 3D ini dibangunkan dengan menggunakan model ADDIE. Reka bentuk penyelidikan utama yang digunakan dalam kajian ini bagi menentukan kesan perisian tersebut adalah kuasi-eksperimen menggunakan ujian-pra dan ujian-pasca. Instrumen yang digunakan dalam kajian ini terdiri daripada ujian-pra dan ujian-pasca serta set borang soal selidik bagi mengukur persepsi pengguna ke atas kebolehgunaan perisian tersebut. Sampel kajian terdiri daripada 54 pelajar yang dipilih secara rawak kepada satu kumpulan kawalan (n=27) dan satu kumpulan rawatan (n=27). Ujian-pra dan ujian-pasca dijalankan terhadap kedua-dua kumpulan tersebut. Borang soal selidik System Usability Scale (SUS) diberikan kepada kumpulan rawatan untuk menentukan kebolehgunaan perisian ARC-3DM selepas rawatan. Statistik deskriptif dan inferensi seperti peratusan, min, sisihan piawai, dan ANCOVA telah digunakan bagi menganalisis data empirikal. Analisis kovarian (ANCOVA), dengan skor ujian-pra sebagai kovariat, dijalankan pada $\alpha = 0.05$ tahap signifikan. Dapatan utama dari ANCOVA [$F(1, 51) = 133.91$; $p < 0.05$] menunjukkan bahawa ujian-pasca dari kumpulan rawatan (M=70.69; SD=17.25) adalah lebih signifikan dari ujian-pasca dari kumpulan kawalan (M=53.48; SD=16.55). Ini menunjukkan bahawa selepas empat-minggu rawatan, kumpulan eksperimen rawatan telah mencapai prestasi lebih baik bagi tugasan pemodelan 3D berbanding dengan kumpulan kawalan. Di samping itu, berdasarkan kepada borang soal selidik SUS, majoriti (85%) responden bersetuju bahawa ARC-3DM dapat membantu dan bersifat mesra-pengguna dalam meningkatkan kemahiran mereka dalam pemodelan 3D. Sebagai penutup, perisian ARC-3DM dikenal pasti sebagai efektif dan berguna dalam membantu meningkatkan kompetensi pengguna dalam kemahiran pemodelan 3D. Implikasi dari hasil kajian ini mencadangkan bahawa pengintegrasian teknologi augmented reality ke dalam suasana pembelajaran dapat mengoptimumkan pengalaman pembelajaran di samping dapat meningkatkan kemahiran pemodelan 3D di kalangan pelajar. Aplikasi ini boleh digunakan sebagai alat pembelajaran baru bagi membantu pelajar dalam mempelajari pemodelan 3D dengan lebih efektif.

Kata Kunci: Perisian augmented reality, Prestasi pemodelan 3D, Keberkesanan dan kebolehgunaan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

3D	Three dimensional
ADDIE	Analyze, Design, Develop, Implement, and Evaluate
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
AR	Augmented Reality
ARC-3DM	Augmented Reality Courseware for 3D Modelling
CSUQ	Computer System Usability Questionnaire
DBaaS	Database as a Service
DDR	Design Development Research
DV	Dependent Variable
GUI	Graphical user interface
HCI	Human-computer Interaction
HIT	Human Interface Technology
HMD	Head mounted display
HuMAR	Human Anatomy in Mobile Augmented Reality
ICT	Information and communication technologies
IOT	Internet Of Things
IV	Independent variable
IT	Information technologies
KKTI	Teluk Intan Community College

MAR	Mobile Augmented Reality
MARS	Mobile augmented reality system
MdeC	Multimedia Development Corporation
MMU	Multimedia University
MR	Mix Reality
MRS	Mental Rotation Skill
NHEAP	National Higher Education Strategies Plan
OST-HMD	Optical See-through Head Mounted Display
PTCE	Performance Test on Current Electricity
QR	Quick Respond
QUIS	Questionnaire for User Interface Satisfaction
RE	Real Environment
SPSS	Statistical Package for the Social Sciences
SUS	System Usability Scale
SVS	Spatial Visualization Skills
TI	Target Image
UAV	Unmanned Aerial Vehicles
UI	User Interface
UNC	University of North Carolina
UX	User Experience
VBI	Vision-based interface
VCASS	Visually Coupled Airborne Systems Simulator
VE	Virtual Environment
VIVED	Virtual Visual Environment Display

VR	Virtual Reality
VRD	Virtual Retinal Display

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

3D Animation industry in Malaysia has shown a significant growth over the last few years with some successful projects such as the first computer-animated film “Geng: The Adventure Begins” which released in 2009 by Les’ Copaque Production. Another example is the “War Of The Worlds: Goliath” which produced in 2012 by Tripod Entertainment which had its first international premiere at the famed San Diego Comic Convention (The Star Online, 2014). With the support from government through the Multimedia Development Corporation (MdeC), animation industry is currently growing at an explosive rate in Malaysia. Therefore, the demand for creative talent has also been increasing exponentially.

Juhaidah Joemin who is the co-founder and Head of Production at Giggle Garage which based in Cyberjaya Malaysia mentioned in her speech that:

> The country needs at least 4,000 animators to meet the high demand, but we are barely producing 1,000 graduates per year.
>
> (Penang Monthly, 2015)

Multimedia University (MMU) Faculty of Creative Multimedia Animation and Visual Effects Programme coordinator, Yusran Mazalan was mentioned in New Straits Times online dated April 18, 2016 who agreed that talent is an issue in the animation industry. He stated that:

> The industry has grown tremendously and will continue to do so. There are a lot of animation-related jobs in the near future. To be part of the industry, one must possess both technical (software) and practical skills in animation production.
>
> (New Straits Times, 2016)

In order to meet the demand of the industry, Malaysia need to produce a great amount of animation graduates with high competency in both technical in 3D animation software and the practical skills in animation production. According to King (2014), learning 3D animation is not a simple task because it involves complicated instructions, which could be a painstaking process. Therefore, educators

need to search for creative and innovative ways to teach 3D animation which can help enhance the efficacy of students' learning and academic achievement (Khan, 2002).

In Teluk Intan Community College (KKTI), the teaching and learning process for 3D animation is conduct using written tutorial. The written tutorial serve as a guideline for an animation processes which states the instructions that a student need to follow in creating 3D animation project using the Autodesk Maya software. The written tutorial is consisting of only two elements of medias, which are the text and graphic. Studies by Kramer, Olson and Walker (2018) shows that the lack in interactivity made the written tutorial fail to attract the attention of the students. This is often resulted in student did poorly in the practical assignments given which also effect the overall achievement.

Aloraini (2005) stated that multimedia could be considered to be one of the best educational techniques when it can address more than one sense simultaneously, as it addresses the senses of sight and hearing which provide different stimuli in presentations. With this, complicated process in 3D animation could be conveyed and demonstrated interactively in a more natural and intuitive way. Aside from embodied interactions with digital information within multimedia, studies by Fujimoto et al. (2013) have shown that presenting digital information together with the context of a real environment also helps memorization. The coexistence of digital information with real environment is one of the characteristic in the Augmented Reality (AR) technology.

1.2 Problem Statement

3D animation is produce in three phases, which are the pre-production, production and post-production. Technically, animation students will be using the 3D animation software and other related software to produce the 3D animation project. The focus of this study is on the second phase, which is the production. The topic selected for the phase of production will be the 3D modelling. The reason why the topic of 3D modelling is chosen is because it is based on the current syllabus offered in 3D animation course in KKTI. In the syllabus, the course only covers production phase which starts with 3D modelling continuing with 3D texturing and finally 3D lighting and rendering using the Autodesk Maya as the 3D modelling software. It is important to strengthen the 3D modelling skill so that the students should be able to produce 3D models at satisfactory level before proceeding to the next steps according to the syllabus.

There are some problems with using the conventional method of written tutorial. Written tutorial is a traditional printed paper and with students with low spatial skills leads to students cannot visualize the object to be modelled in three dimensional (3D) which resulted in students producing 3D models at unsatisfactory level or in the worst case scenario, even failing to complete the assignment or project given. The lack in interactivity made the written tutorial fail to attract the attention of the students (Kramer, Olson & Walker, 2018) which often resulted in student did poorly in the practical assignments, which also effect the overall achievement.

Percentage of students in KKTI with high achievement has dropped compare to previous year (Figure 1.1).

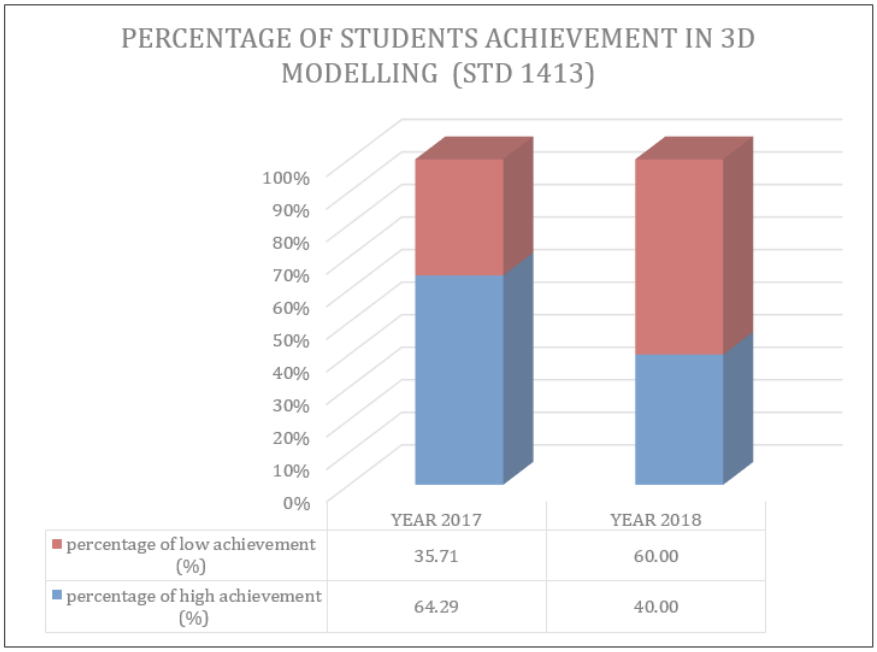

Figure 1.1. Percentage of Students Achievement in 3D Modelling (STD 1413) in KKTI

The results from interviews with lecturers or experts (L1, L2 & L3) from KKTI has also found out that the students are not competent enough in 3D modelling and failed to meet industry standards.

L1 "…When the students were asked to model 3D objects, most of the 3D models done by the students fails to capture and display the details which the object should have. The students seem like they don't know how to utilize the basic tool in 3D modelling application effectively or they might have problem imagining the object they were going to model in three dimensional..."

L2 "…There are only a few students that are good in 3D modelling but most of the students are not that good in 3D modelling. The students took a lot of time to model a 3D object even for a simple object. The students cannot utilize the 3D tools effectively thus consuming too much time on a 3D modelling task. The 3D models done by the students also have too much unnecessary lines and faces which made the size of the 3D model files heavy and less effective for production…"

L3 "…The students have problem to model a 3D model from illustration or a picture, especially an imaginative object. The 3D model done by students referring from pictures looks distorted and fails to capture the details like shown in the referred picture. The proportion and the ratio of the 3D models sometimes off. Most of the students also cannot manage the time properly. They should model the basic shapes first and only after that editing the details from the reference picture …"

Thus, the development of AR tool which later be called as ARC-3DM (Augmented Reality Courseware for 3D Modelling) will help to solve the students' difficulties in visualizing 3D models and also attract attention thus help the students to model 3D object at satisfactory level. The ARC-3DM will also be integrated with other multimedia elements such as interactivity, graphic, text and audio narration based on constructivism and cognitive theories.

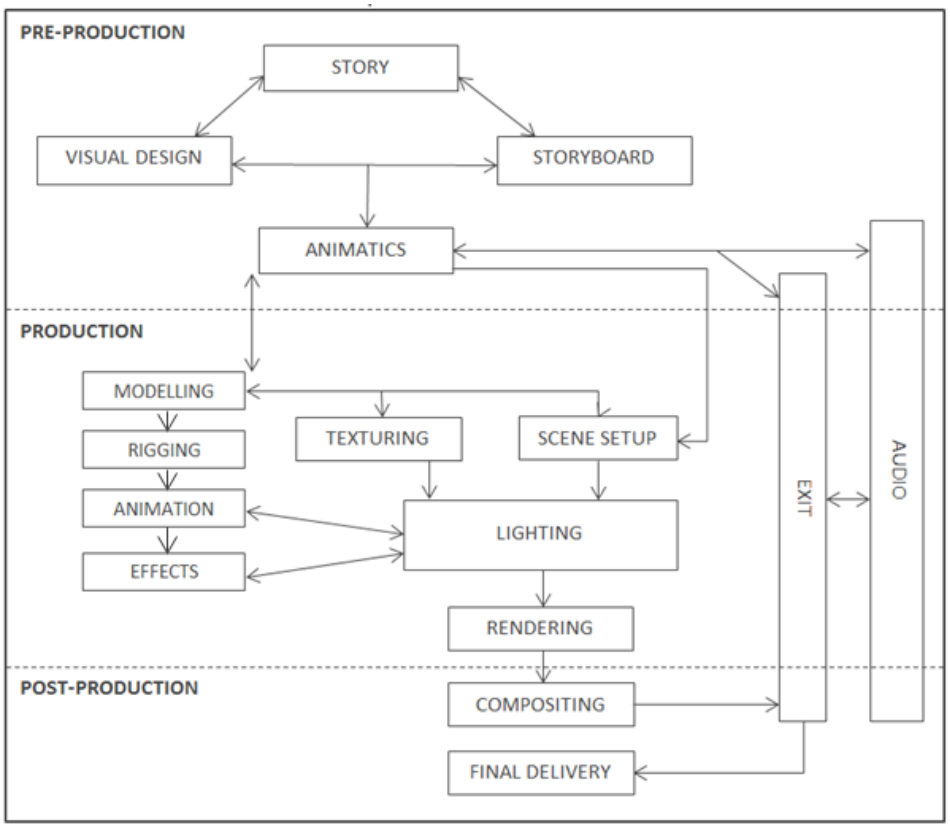

Figure 1.2. 3D Animation Process and Workflow. Adapted from Gridway Digital, 2014

As illustrated in Figure 1.2 3D Animation Process and Workflow, the second phase which is the production starts with the task of building the props, environment and characters, which commonly known as 3D modelling. Remondino and El-Hakim (2006) in their studies mentioned that 3D modelling can be seen as the complete process that starts from data acquisition and ends with a 3D virtual model visually interactive on a computer, which meant only as the process of converting a measured point cloud into a triangulated network (‘‘mesh’’) or textured surface. Therefore, modelling is the process of taking a shape and molding it into a completed 3D mesh. According to the Autodesk Knowledge Network (2017), the common way of creating a 3D model is to take a simple object, called a primitive, and grow it into desired shape that can be refined and detailed. Primitives can be anything from a single point

(called a vertex), a two-dimensional line (an edge), a curve (a spline), to three-dimensional objects (faces or polygons). Using the specific tools featured in the 3D software, the 3D primitives can be manipulated into desired 3D object. There will be basic methods or steps in manipulating the 3D primitives, therefore it is important to understand how the tool works for each technique. In the production stage, 3D modelling will involve the making of 3D modelling of characters, props and the environment or background for the scene setup.

1.3 Research Objectives, Questions and Hypotheses

The purpose of defining the research objective is to specify the intended outcome of the research study. Research objectives should be the key outcomes focused on what to achieve rather than what the researcher intended to do. According to NSW Environmental Trust (2011), objectives should be specific, measurable, attainable, resourced and could be achieved within certain timeframe. Specific means that the objectives should be clear and unambiguous. Objectives should be measurable so that the achievement level could be tracked, demonstrated and compare. Researcher should also ensure that the objectives are attainable or realistically achievable. Therefore, it should be suitably resourced which means that it should easily gain access to its necessary tools. The researcher should ensure that the objectives meet a certain dateline or timeframe so that the achievable level could be measured. For this research, the intended outcome is to compare the effectiveness between using the learning tool and without using it. The perception of students after using the AR tool

in the aspect of usability will also be discussed. Three usability factors were used to evaluate the courseware which will be the effectiveness, efficiency, and overall ease of use. Table 1.1 shows the research questions and research objectives specifically design for this research.

Table 1.1

Research Questions and Research Objectives

	Research Questions		Research Objectives
1.	What is the suitable method to evaluate students' achievement for the topic of 3D modelling?	1.	To design and develop the AR tool (ARC-3DM).
2.	Is there any significant difference between students' achievement in the treatment group and the control group after using the ARC-3DM compare to the conventional method?	2.	To evaluate and discuss the effectiveness of using the AR tool (ARC-3DM) on students' achievement compare to the conventional method in the task of 3D modelling.
3.	What are the students' perceptions on the usability of ARC-3DM?	3.	To evaluate and discuss the usability of ARC-3DM in the task of 3D modelling.

Research and Statistical Hypotheses:

A hypothesis is a specific statement of prediction. Hypothesis is use to answer the research questions. The hypotheses designed for this study are:

H_1 : There will be significant difference in the means of students' achievement between the treatment group and the control group after using the ARC-3DM compare to the conventional method when the pretest is adjusted.

H_0 : There will be no significant difference in the means of students' achievement between the treatment group and the control group after using the ARC-3DM compare to the conventional method when the pretest is adjusted.

H_A : There will be significant difference in the means of students' achievement between the treatment group and the control group after using the ARC-3DM compare to the conventional method when the pretest is adjusted.

1.4 Significant of the Research

This study is a way to breakthrough from the norms in community college education system as well as to provide insight and to promote the implementation of AR technology into the community college education system. The aim of this research is to evaluate the effectiveness and usability of integrating the Augmented Reality (AR) technology as an aid for animation course in Teluk Intan Community College (KKTI). The focus was to integrate AR tool as an aid for students in the task of 3D modelling. For this research, the intended outcome is to compare the effectiveness between using the AR tool and written tutorial. A study conducted by Su et al. (2014) has found that the AR tool has a significant supplemental learning effect as a computer-aided learning tool. Lecturers as the agents in delivering the knowledge in KKTI could hopefully utilize the ARC-3DM as an innovation for a greater change in the current teaching and learning environment. With the emerging of information and

communication technologies (ICT), it is important for lecturers to think and evaluate the current methods and pedagogical used to promote innovation in the learning environment (Aurora & Clara, 2011).

In this study, the sample are among the animation students of KKTI. The reason why KKTI was chosen is that it offers 3D animation course at the lowest education level, which is at certificate level. In order for the animation students who graduated at certificate level to compete in the industry or to further their study in higher level such as diploma and even at degree level, they need to have sufficient amount of competency level to survive for the next level.

In the effort to generate more generation with creativity, innovative and could compete globally, the findings from this study are important to take note of. The findings will show the quality of teaching and learning and the current achievement of students in 3D animation course. This will provide an insight in the effort to increase the quality of teaching and learning process through variety of methods related to 3D animation field. In addition, this study will also provide benefit to third parties such as the lecturers in other higher education institutions who teaches in the field of animation to plan proper activity and method to optimize the learning experience. This study also could serve as a reference and guideline for students who undertaking 3D animation course using latest technologies.

1.5 Research Scope and Limitations

For this research, the scope and limitations identified is illustrated in Figure 1.3. Research Scope and Limitations. The study will be conducted in only one community college in the state of Perak which is Teluk Intan Community College (KKTI). The reason is because, the method of research sampling for this research is using cluster sampling followed by random selection. The cluster sampling was based on the cities which offers the course of animation in community college. In this case, there are five cities of community colleges that offers animation. However, the focus for this research is only on a certain type of animation which is the 3D animation at certificate level. Therefore, the community colleges that offers 2D animation are excluded including the community colleges that offers 3D animation at diploma level. Random selection was conducted on KKTI to collect the sample research.

The development and evaluation of ARC-3DM will only be based on the syllabus or curriculum of Certificate of 3D animation provided from KKTI. For the sample collected, only students undertaking the 3D animation course in KKTI will be selected. During the pretest and posttest, students will be asked to model 3D object using a 3D software chosen specifically which is Autodesk Maya. Maya is chosen because it is the 3D software currently used by the KKTI animation students in accordance with the current syllabus. For this research, the ARC-3DM will only be utilized in the topic of 3D modelling.

The research is conducted to observe how the use of ARC-3DM in teaching and learning environment in community college affect the students' achievement for

the topic of 3D modelling. The researcher is well informed that there are other factors could contribute to the effect on students' achievement. However, the researcher hope that this research will give an overview to other researchers who are also researching in the same area and thus help expand and contribute the knowledge to other areas due to research limitations.

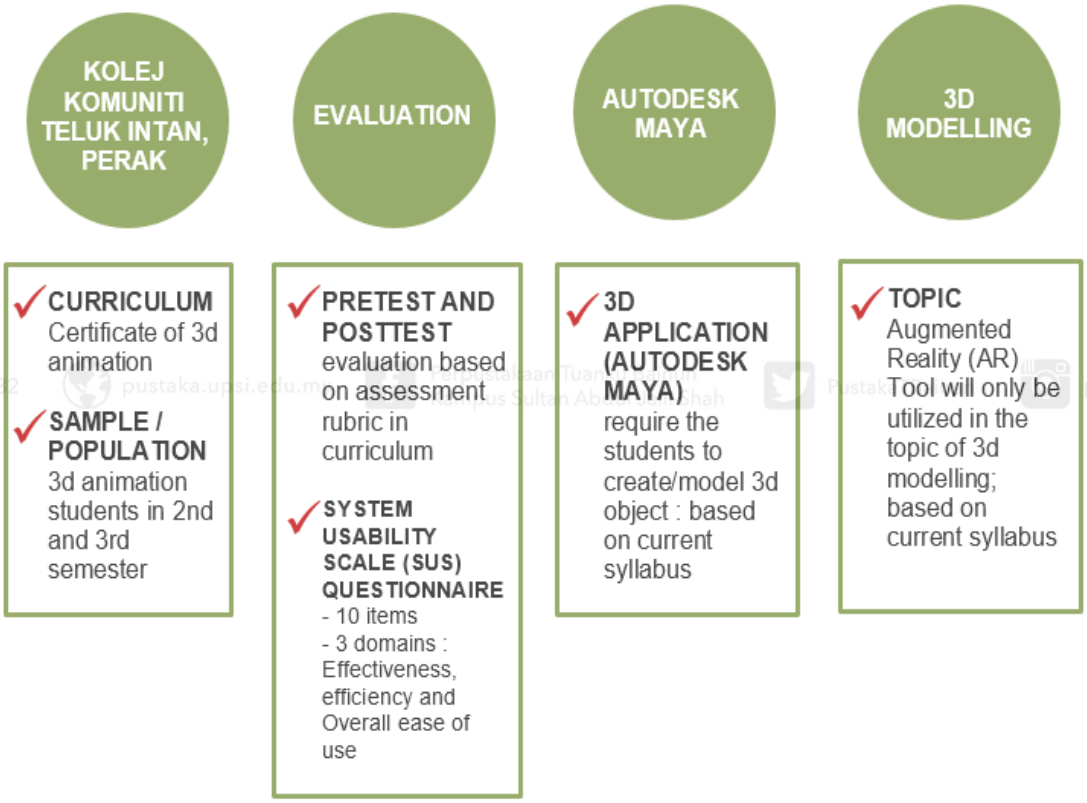

Figure 1.3. Research Scope and Limitations

1.6 Operational Definition

Augmented Reality (AR)

Augmented reality (AR) is the seamless integration of virtual objects and real environments (Azuma 1997). In the Augmented Reality (AR) environment, computer-generated information is placed in the world as if they coexist with real objects. For the development of ARC-3DM, the learning contents are presented using Augmented Reality (AR) as a platform aided with 3D visualization and other multimedia elements to increase learning experience.

Multimedia

According to (Sethi, 2005) and (Mayer, 2001), multimedia refers to the integration of two or more different information media within a computer system. These media can include text, images, audio, video, and animation. Vaughan (2011) defined multimedia as a combination of digitally manipulated text, photographs, graphic art, sound, animation, and video elements. We can conclude that multimedia uses a combination of different media such as text, audio, images, animations, video and interactive content. For the development of the ARC-3DM, all the learning content and 3D visualization are combined with other media elements such as illustration, text, audio narration and interactivity to produce a multimedia courseware.

Students' Achievement

Students' achievement refers to the difference in scores between Pretest and Posttest. For the Pretest and Posttest, student will be guided to do practical assignment under the topic of 3D modelling. Students will be ask to create 3D model using tools in the

Autodesk MAYA software following certain guideline and regulation. The competency level for the pretest and posttest will be measured in the aspects of time management, technicality skill, visual outlook of the 3D model as well as its similarity or resemblance of the 3D model to the reference object. The total marks for the pretest is 100 and the same goes for the posttest which is also 100 mark. The pretest and posttest are measured using the evaluation rubric provided in the curriculum of Certificate of 3D Animation in Community College.

Conventional Method in Teaching and Learning

Conventional method in teaching and learning refers to the written tutorial that consist of only two elements of media which are the text and graphic provided by the curriculum committee in the Department of Community College, Ministry of Higher Education.

Perception and Usability on ARC-3DM

To evaluate the perception on ARC-3DM, a Questionnaire will be administered to each of the respondent from experimental group to answer. The questionnaire which act as one of the instrument for this research aims to provide students' perception and evaluation on the usability of ARC-3DM. As illustrated in Figure 1.4 Questionnaire Framework, the items in questionnaire are adapted through the System Usability Scale (SUS) which constructed by John Brooke in the year of 1986. The questionnaire will have 10 items which covers the aspects of effectiveness, efficiency, and overall ease of use.

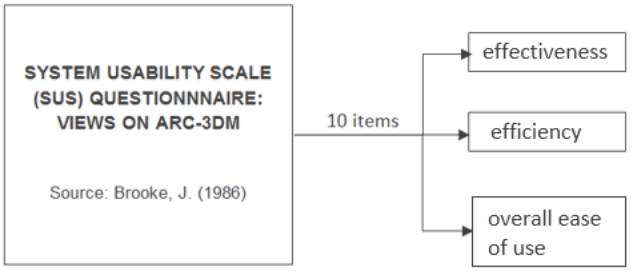

Figure 1.4. Questionnaire Framework. Adapted from Brooke, J. (1980)

ARC-3DM

ARC-3DM is a short form and defined as Augmented Reality Courseware for 3D Modelling. It is one of the main instrument being used in this research to evaluate its effectiveness and usability as an aid in executing the task of 3D modelling. ARC-3DM utilized the mobile-augmented reality (MAR) technology and also implements the technology of marker-based augmented reality combined with multimedia elements. By integrating augmented reality (AR) technology into the ARC-3DM, it helps to improve and increase the Spatial Visualization Skill (SVS). With the addition of multimedia elements into the ARC-3DM by implementing the Mayer's Theory, overloaded in cognitive load of memory could also be avoided. All of these features aims to stimulate and promotes learning effect as well as an aid for executing the task of 3D modelling.