

# Preliminary analysis of “The Effectiveness of using Virtual Reality approach in Electromagnetic Theory Subject Courseware” in MTUN.

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## Abstract

This paper is about the study of applying a virtual reality approaches on studying electromagnetic theory. It will examine the effectiveness of this approach in the field of education as some subject need high imagination to understand. This topic has cover about the surface of 3D environment and the usage plus the impact of the virtual reality approaches in this project. It also explains about the problem that has been found until the development of the courseware with virtual reality approach. This project focus for students and lecturers guideline, and will exposed them to the used of ICT and multimedia tool in learning as one of the teaching tool. Data have been collected by using questionnaire method, which four Malaysia technical universities have been chosen to prove that Electromagnetic Theory (EMT) subject is the hardest subject in engineering field as it is the fundamental subject for future engineer. At first, 16 objectives question have been given to 10% student those have took the subject before for each universities. These questions are to test their understanding about EMT subject, as before they were using traditional approach in their study. All questions are from four subtopic in the EMT subject, which are Vector calculus, Electrostatic, Magnetostatic, and Wave application. Each subtopic contains four questions. Then analysis have been done to check the most hardest subtopic so that it will be chosen as a main subtopic that will be focus on, which 3D and Virtual reality approach will be applied on it. It is believe that the effectiveness of these approaches can be seen if the method applies in the hardest part gives positives results. Not only survey on students have been done, but also to the lecturer's and as a same method, 10 % of survey from lecturers that teach EMT subject in all Malaysia Technical Universities have been taken, and analysis have been done, as a result most lecturers agreed if 3D and Virtual reality approaches applied in studying the subject to make students easily understand about the subject as this subject need high imagination. This paper presents a summary of the experimental assessment process and findings regarding the educational value of the multimedia courseware with three dimensional and virtual reality approaches applied.

## Introduction

In our world today, education is very important thing that must be embedded in each self. Nowadays there are a lot of ways on delivering knowledge to public such as book, network, computer, laboratory, research and many more. Most likely used is computer, because it is interesting and attractive. By using computer, some virtual element can be used. Virtual reality is a technology that allowed individual to explore multimedia environment in a real time. It is usually developed in a three dimension (3D) view. According to Nicole Strangman and Tracey Hall, virtual reality (VR) is a computer-based technology that provides visual, aural and tactile stimuli of a world and usually applied 3D environments that generated in real time, (Strangman & Hall, 2003). Usually this technology always used and applied in military, health, entertainment and now it is also start applied in education. For education, virtual reality approach always being used when teaches about space and robotic because both of this field is very expensive in real world. However, this

approach also as a welcome alternative conventional study of science and mathematics, which require students to develop understanding based on textual description and 3D representations. Virtual reality is one of the applications in information communication technology (ICT).

According to Malaysia's Prime Minister, Dato' Seri Najib Tun Razak on article from the Sun, date 10 November 2009, he said:

The ministries must take pro-active action to maximize the use of ICT in the delivery of public services because it can improve the quality of life of the people and the image of the government. It had to be building the types of services the public needed and expected, including making full use of available multimedia tools, mobile access devices and social networking on internet. Only when citizens utilize the services and derive benefit from it, we can consider that successful delivery of public services.

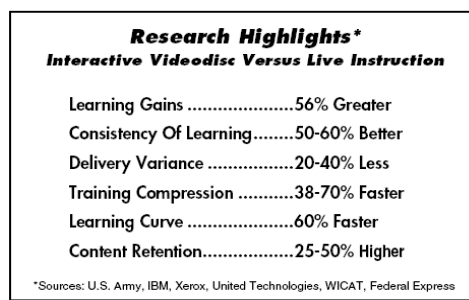
This statement means that ICT plays an important role in our life nowadays, and it can be one of the main steps to improve community's quality of life. It will show the standard of the country I community knows the ICT and can show to the outsiders or can be as strong as another strong and huge country. It also can be seen when United Kingdom (UK) governments also push their community to learn and know about ICT as their British government provides internet access to all community in 2005. These intend to offer computing services, easy access to government portal, learning for student and enhance ICT skills especially in education. It shows that ICT plays important role in gaining knowledge and study (Gaved, M., and Anderson, B. 2006).

This paper is about to develop a courseware that will be focus to Universiti Teknikal Malaysia Melaka (UTeM) students who are from Faculty of Electrical Engineering (FKE) and Faculty of Electronics and Computer Engineering (FKEKK). Besides that, not only student can use this tool, but lecturer also can use this tool to teach their student and to do revision. This courseware will develop for subject Electromagnetic Theory (BEKP 3553), however it is not develop for the whole subject, and only one topic will be cover, which is Vector Calculus. The whole chapter will be animated by using multimedia elements, but the main sub-topic will be focus is coordinate system and transformation. This sub topic will be developing using 3D approach and virtual elements will be added. The main purpose on developing this courseware is it focuses on explaining the constant-coordinate surface in the object using 3D and virtual environment. It will cover the three type of object which are spherical coordinate, cylindrical coordinate, and planar coordinate. Meanwhile, the other sub-topic will be explained in 3D environment without virtual environment.

This topic has been chosen because from the surveys that has been done, most of lecturers said that this topic is the hardest for UTeM's student s to understand. Besides that, according to Matthew N. O.SADIKU (2008), this topic is the most difficult topic in the world for student to understand. This topic is important as it is the key to other topic behind engineering world. By using this approach, it will make students more understand about constant-coordinate surfaces as they can feel it in real time and see how it is working. By using this courseware, student can learn alone, and do revision rapidly by themselves plus they can do practice at home regularly. Only selected sub-topic will be done in virtual reality, and the rest of the experiments will be develop in three dimension approach so that it still can be attractive and the whole activities will be interactive, this is to avoid students from feel boring and unhappy while using the courseware.

This approach has been chosen which is virtual reality and 3D environment because it will help students who are not interested in study through text which they can learn more on using symbols, besides that the multisensory nature can be especially helpful to students who are less visual learners, (Strangman & Hall, 2003, pg 3). Hence, the related of using virtual reality with education because it enables first person experience, which are natural, unreflected and personal, generating direct, subjective and gain personal knowledge. Virtual reality also provides less symbolic interaction with the environment. Any description of an experience or action is usually transmitted through symbols, conventions and formalism, meaning that traditional learning of a concept requires previous knowledge of symbol, (Sanchez, Lumbreras, and Silva). According to Bailenson et al, the strongest reason using virtual environment is that the ability to implement contexts and relationships not possible to achieve in a traditional learning setting. Besides that, it can simulate the dangerous or expensive lessons. In this project case, this methods apply is to change from traditional method which are lecturers have to bring something that look alike 3D stuff such as can or orange just to create high imagination on study while learning this subject.

By using the courseware, it is more interactive, and research has been done by Gregory L. Adams (1995), the result of the research is as shows in figure 1.1, which is the research on interactive videodisc versus live instruction.



**Figure 1.1 Research Highlight Interactive Videodisc versus Live Instruction**  
**Source: Gregory L. Adams (1995)**

“According to Gregory L. Adams (1995), from the research we can see that in the field of learning gains, students will gain knowledge better than using traditional approach, which means knowledge can get more by using courseware. Consistency of learning also will be increases to 50 - 60 % better than traditional approach. Delivery variance is to measure how consistently the delivery media presented the content from learner to learner or class to class. That is mean, student can understand better when using courseware as they will less asking for misunderstand. Training compression and learning curve is to show that how much faster user done their work using courseware and now it provided the work can be done and understand faster than usual approach. And the last one is, content retention is to show how long the memory of the study can be saved, and now it shows that long term memory can be used when using the interactive assessment courseware”.

This courseware was developed to help students more understand about constant-coordinate surface concept as it is presented in virtual reality environment with 3D approach, attractive, interactive animation, games and quizzes. The delivery of the courseware via network, make

students easy to access the system. For virtual reality segment, user need to used Head Mounted Display (HMD) and Glove to access the knowledge.

For virtual reality, there are divided into several ways on delivering the usage of it. First, it can be deliver using visual which use of head mounted display (HMD), next is auditory which wearing earphone to help localization sound in virtual environment, third is haptic which wearing gloves that use mechanical feedback or air blast system that simulate contact with virtual environments and finally olfactory which user can smell a thing from virtual environments, this approach always used in Japan technology, (Bailenson etl, 2008, pg 103-104). Below are figures of some hardware that used in virtual reality.

## Objectives

The main purpose of this research is to measure the effectiveness on using VR and simulation in study and there are several ideas on the reason of developing this virtual reality courseware. The objectives of this research are:

- i) To develop a virtual reality/simulation courseware.
- ii) To measure the effectiveness of problem scenario presentation between conventional study and courseware using simulation.
- iii) To expose for Information Technology.

## Preliminary Analysis

As a first step on identifying problem for this research, preliminary analysis has been done to identify the classes of student on learning this EMT subject. This analysis is to find the most difficult topic in the EMT subject that need extremely high imagination by students, moreover it to prove that constant-coordinate surface is the most difficult topic in that subject. All four MTUN universities have been chosen to test on student that already taken the subject, besides results for three semesters back also has been taken and analyze.

After some analysis have been done on the data taken, the results for past years student show that most of the student got result C to C+ only. The semester that been taken is from sem 1 2007/2008, sem 1 2008/2009 and sem 1 2009/2010. It proven with the mean or also known as average with the range from 59 to 62, the differences between the years is not so much. Besides that the median shows that middle number is from range 58 to 61, it is not far from the average marks or three semesters. Below is the table on summarizing the three semesters back results:

Table 1.1 Three years back result for EMT subject

		<b>Statistics</b>		
		<b>Sem_0910</b>	<b>Sem_0809</b>	<b>Sem_0708</b>
N	Valid	59	55	70
	Missing	11	15	0
Mean		59.6259	62.8169	60.3102
Median		58.1700	61.9300	59.0250
Mode		75.97	61.93 <sup>a</sup>	58.03

Std. Deviation	9.94716	10.46916	10.78387
Variance	98.946	109.603	116.292
Minimum	44.97	41.98	36.46
Maximum	84.60	83.42	87.19

One of the research method has been apply while doing the analysis, which are few questionnaires have been given to the student that already took this subject and face the examination. Questionnaires given to all four MTUN universities, with the total of students are 176 student that have been took the subject and 8 lecturers for EMT subject to completed the analysis. Respondents will marks their opinion based on Likert Scale that already applied in the questionnaires. The scale is from 1= Easy, 2 = Hard, 3 = Harder, and 4 = Hardest.

Table 1.3 shows mean of difficulties of topics according to students and lecturers. Both of response quote Coordinates System and Transformation as the most hardest topic to learn and to teach, it shows that student mean is 2.74 while lecturers is 3.00.

Table 1.2 Mean the difficulties of subject according to lecturers and students

Chapter	Topic	Students (n=176)	Lecturers (n=8)
		Min	Min
1	Vector Calculus		
	a. Pre-calculus (Vector Algebra)	1.78	1.5
	b. Coordinate System and Transformation	2.74	3
	c. Calculus in Electromagnetic Application	2.01	2.75
2	Electrostatics		
	a. Introduction to Electrostatics	1.7	1.25
	b. Coulumb's Law	1.85	2
	c. Gauss's Law	1.89	2.5
	d. Electrical Potential	2.07	2
	e. Current and Conductors	2.16	2.25
	f. Dielectrics & Boundary Conditions	2.34	1
	g. Capacitance	2.25	2
3	Magnetostatics		
	a. Introduction to Magnetostatics	1.97	1.25
	b. Biot-Savart's Law	2.29	2.5
	c. Ampere's Law	2.28	1
	d. Magnetic Flux Density	2.43	2.25
	e. Magnetic Forces	2.37	2.5
	f. Boundary Condition	2.6	2.5
4	Wave Application		
	a. Introduction	1.88	1.5
	b. Faraday's Law	2.22	2.5
	bi. Transformer & Motional Electromotive Forces	2.66	2.5
	c. Maxwell's Equation	2.56	2.25

d. Wave Propagation	2.64	1.75
di. Wave Equation in General	2.61	1.75
dii. Wave propagation in Lossy Dielectrics	2.69	1.75
diii. Wave Equation in Free Space	2.66	1.75
div. Wave Equation in good Conductor	2.71	1.75
e. Poynting Vector	2.42	2.25

Moreover the next results shows that students are weak in this EMT subject, it proven when 16 objectives question have been given to theme which are 176 students from every MTUN universities, and they have to answer all the question in an hour, as a results most of the students only can answer 4 to 8 question with correct answer, that means they only got half of the marks from overall subject. The test paper includes all question from all topics in EMT subject, Reference D shows the list of question. Table 1.3 shows the summary of the analysis.

Table 1.3 Analysis on test result

Question No	Learning Outcomes	Student's Answer	
		TRUE(%)	FALSE(%)
1	Vector Calculus	44.32	55.68
2	Vector Calculus	33.52	66.48
3	Vector Calculus	18.75	81.25
4	Vector Calculus	12.5	87.5
5	Electrostatics	41.48	58.52
6	Electrostatics	25.57	74.43
7	Electrostatics	23.86	76.14
8	Electrostatics	46.02	53.98
9	Magnetostatics	72.73	27.27
10	Magnetostatics	28.98	71.02
11	Magnetostatics	32.39	67.61
12	Magnetostatics	36.36	63.64
13	Wave Application	38.07	61.93
14	Wave Application	15.91	84.09
15	Wave Application	14.2	85.8
16	Wave Application	16.45	83.55

## Problem Statements

The main research problem of this project is to investigate the effectiveness of the used of the virtual reality with three dimensional environments (3D) while learning Electromagnetic Theory for UTeM's students.

Nowadays, not most of the courseware that developed using 3D environment and virtual reality that focus on electromagnetic theory. So, the development of this courseware really hope can help students perform well in examination, and more understand in their study. This courseware provided with tutorial so that, student can answer all question based on what that they have learned. Besides that, the whole topic in this courseware are developed using 3D environment and some of

them find so hard to understand are developed using virtual reality approach. From the research that have been done, it is found that learning using 3D environment with virtual reality approach have high potential to situate learner within a meaningful context to a much greater extent than a traditional interactive multimedia environment, (Dalgarno and Hedberg, 2001, pg 34).

They also will get additional information about what those have been done. Digital educational technologies promise increased power of investigation, but are likely to do little more than compound the confusion unless critically understood and distinguished from their subjects of investigation. These descriptions and explanations are used to examine and raise concerns about the application of current educational technologies, all the while exposing several epistemological fallacies about those technologies. Recommendations are made to aid students and teachers in distinguishing tools from tasks an epistemological discipline so that tools or technologies will appropriately serve as "means" to a subject's investigation, not as ends (Beatham, 2009).

As for this topic, not all student can easily visualize about constant-coordinate surface, they cannot imagine how to do the calculation if question need the inside number of the object, so the purpose of this courseware development is to help them to visualize and train them to have high imagination. Most of study style nowadays is bored; there is no interesting interactivity between students, so a learning courseware will try to build up the interesting in the student feel. As this courseware will provide with the game and assessment, student will feel more interesting to study and they can do everything by their own even without guide from teachers.

Besides that, with the virtual reality embedded in this courseware, students will feel the realism while studying and this will make them more understand about thing that they have learned. Moreover this approach also to make students familiar with the technology, because not all students always play with computer, so the development of interactive courseware can make them used and apply technology in their life especially in their study. In Malaysia education industry, there are still not provided with the use of virtual reality, so the understanding about this approach are too less in Malaysia society, there not mush exposure about this approach. The concept of fun and interactive is provided can give a better effect to physiological and psychological to people event children or adult. They will learn and understand something faster (Lloyd, 1996).

As we all know, this topic is the most important study in engineering field. All of engineering students need to understand the electromagnetic theory especially the constant coordinate surface because it is the major ingredients in part of doing all calculation that will be involved in their study. While using traditional method, students are so hard to imagine the surface to do the calculation, so by using this virtual reality that embedded in this subject, student can easily imagine the surface and the depth of the object to do calculation as they can explore the model by their own, and formula to do the calculation will be appear while exploration is in progress. This will enhance their mind to remember what that have been study while doing the exploration in virtual reality environment besides they can remember the formula easily. By using this way, it will helps student to answer this paper with successfully and more confident to pass the exam.

The purpose on development of this courseware with 3D environment and virtual reality approach is to see the effectiveness of 3D and virtual reality approach in learning electromagnetic theory and to help student to understand more about electromagnetic theory, especially in constant-coordinate surface because it only focus on this topic. This courseware will include with some

activities such as exploration of model of constant-coordinate surface, tutorial, glossary, help or user guide, quizzes and several exam questions. Differences between this courseware from other courseware are 3D environment and virtual reality elements are added. The 3D and virtual reality environment that have been applied such as student can do the exploration to the model so that they will know on doing calculating and it will develop high imagination of the model to do the calculation, so that they will feel like they are in the real world of the object. Human as instructor to user to make user feel the interaction while using the courseware so that they will feel like teachers besides them. 3D elements also applied to navigation buttons in the courseware to make it look real.

Exploration to virtual reality world is the most important purpose of this research because it will focus on the effectiveness of virtual reality to their study. Student will navigate by their own self about the model provided and it will generate formula for student as they can go deeper in the object and rotation will be provided as student can rotate the object to see the back and front face of the object. Glossary used to help them searching some term that they do not understand, and the terminology only covered word from the chosen topic. Help or user guide is to help user who are not familiar with courseware before, so they will used courseware easily if they understand about courseware's concept. Exam question provided so they can answer the entire question, this is a bonus activity that will be added in the courseware.

The goal of this courseware is to make student understand about the electromagnetic theory. Because of that, after accomplish the main activities in this courseware, it will test their understanding by answering questions at the end of the exploration, the question is randomly selected which it is impossible to the same question if the student answer it repeatedly. After answer all the question, marks will be given, and their score will be saved in database, so that they can compare their knowledge from time to time. Besides that, the question provided not just from the constant-coordinate surface, but it is including the whole topic in the electromagnetic theory, so student can eager more knowledge from it.

The most special thing about this courseware is that, one teacher will be provided, and it is in the 3D, so student will feel like they are doing experiments with live teacher, voice also will be added as the teacher can be instructor to the students on doing the exploration. To make the courseware more realistic, the whole equipment will be create in 3D and also the buttons inside the courseware will be in 3D.

## **Research Question**

To achieve this research objective or goal, some research question has been develop, there are:

- Q1. What is the suitable method on developing courseware that will leave better impact to student for their study?
- Q2. Does the courseware with simulation will give good results compare to conventional study?
- Q3. How courseware can give impact on using IT in learning?

## **Research Hypothesis**

Two null hypotheses (Ho) for the research are:



H<sub>0</sub> 1: There is difference on learning performances among students using conventional study and virtual reality courseware.

H<sub>0</sub> 2: There is impact on exposing of IT while using courseware.

## **Project Significant**

There are a lot of significance from this project, and now it can be divided to four categories which are benefits to students, teachers, education industry and school, last but not least to public. The significance of 3D environment and virtual reality approach in education will be discussed as below.

### **Students**

Students will get benefits from this courseware, because not only form three students can use it but the whole lower form. With the virtual reality approach, student can make early study before reaching the next level by using this courseware and they will feel like real on doing the exploration and study. Besides that, they can make fast study, before entering the class. Hence, they will get more information about what they have learned. They can also make revision rapidly because this courseware only focus on same model and it will make student easily to memorize the formula and it is easy to them to imagine the real object while doing examination

Moreover, it can simulate of dangerous or expensive lessons. There is also a line of a research using VE's to teach lessons that either too expensive or dangerous to be conduct b students in physical spaces, (Bailenson etl, 2008, pg 110). By using realistic virtual depictions of dangerous crises, learners can experience the chaos and affective stressors that are typically accompanied with actual crises. The advantages of using this approach, it can decrease the use of money on study, because users do not have to buy many times the material to make the experiments in rapidly time.

### **Teachers**

For teachers, it will help science teacher to teach their student more easily. If it is hard for them to create students imagination, they can use this courseware to create the imagination of student about the model to make them understand about constant coordinate surface. Besides that, teacher can use this courseware to make early preparation before they start to teach their students, will get better understanding about the topic that they want to teach. Hence, if teachers cannot teach their student about the topic, they can leave their student with the courseware to do the exploration by their own, this is good because student will get more knowledge, and it would not be dangerous for student to get done with their experiments without teacher.

### **Education Industry and School**

For educational industry, it will cut coast to buy the material in many time and every year, this industry can save their budget. It is because, if school or industry of education using this approach, they do not have to buy material for many times, besides that, student can do the experiments without buying any material. Besides that, if the whole schools are using this approach,

all of the students will get the same knowledge, either they are living in town, or rural area, or good school and second standard school, all of student swill get the same idea for the topic.

The use of this technology also, will exposed students to use technology, so they would not be too narrow thinking about the technology. In other word, each country will produce society with technology minded.

## **Scope**

The scope of this courseware project can be divided by two which are consumer scope and system scope. In the field of the consumer scope, the target user of this courseware is for engineering students for UTeM. This courseware will only cover the for chapter one in Electromagnetic Theory subject which is Constant-coordinate surface. Electromagnetic theory is generally regarded by most students as one of the most difficult course in physics or electrical engineering curriculum (Sadiku, 2001). The main focus on doing only experiments in this courseware is to test the acceptance and the impact of using 3D environment and virtual reality approach in education for electromagnetic topic. It is only focus on this chapter because from the research that have been done, with the interviewed of lecturers, it shows that student is too difficult to understand and hard to imagine model for doing calculation and sometimes it hard for them to differentiate between other model. Besides that it is the main ingredient on continuing study in engineering field.

In the field of the system scope, the courseware will cover assessment for the whole exploration of constant-coordinate model in chapter electromagnetic theory, there are also notes from the chapter, tutorial, glossary, past year question, virtual reality approach and teacher's voice as a guide to student. There is also a link for the student to get more information about their study in the internet as if they have an internet connection. Sound also will be provided for the user, so that they can listen to the teachers voice, so it will not make them feel boring while using the system. Buttons provided will help user navigate to use the courseware and to save some data. The result for the quiz also can be saved in the database. This courseware will be delivered via internet or network so that it is easy to be access by user. While the use of virtual reality tool is to explore the virtual reality environment that provided in the system.

## **Research Limitation**

This research is divided to two component which first is to develop the 3D and virtual reality courseware for EMT subject, and the second component is to test the effectiveness of the courseware that using virtual reality approach in EMT students that will be test to MTUN universities, which are UteM, UTHM, UMP and UniMAP. This research will include EMT students and EMT lecturer's only that learn electrical engineering course. Only prototype of the courseware that will be use to test and see the effectiveness of the virtual reality to create students high imagination so tat students can easily undersatnd the subject if their lecturers not besides them. This research only focus for only one topic EMT, constant-coordinate surface which is the hardest part of the EMT subject. It is because the topic is the basic to the other topic.

The development of EMT virtual reality approach courseware is only focus on constant-coordinate surface topic, and other topic will be buid with non-virtual environment. This

courseware will be delivered through internet which means web-based and also can be delivered via compact disc (CD) because it can be a stand-alone product. If users use the internet, they have to register their name with admin, because only authorised students can access to use the courseware, especially for persons who only learn electromagnetic fields and their scores and data will be saved in the data.

## Conclusion

As a conclusion, this topic covers about the surface of 3D environment and the usage plus the impact of the virtual reality approaches in this project. It also explains about the problem that has been found until the development of the courseware with 3D environment and virtual reality approach. The benefits and significance of the project also have been discussed in this topic, and found that there are a lot of benefits will be gained if this method applied in education industry.

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