Virtual Environment Courseware in Engineering Drawing to Enhance Students’ Visualization Skills

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Abstract: Virtual environment for education have been discussed in various ways. A virtual learning environment plays an important role in one of the main aims of education and it is designed to educate the user either in school level or at higher learning institutions. On the other hand, visualization skills are very important in engineering field and it is positively correlated with achievement in engineering disciplines. This study examined the effect of virtual environment courseware in learning engineering drawing toward students’ visualization skills. The finding of this study revealed that the virtual environment courseware teaching method is able to encourage students to participate actively in teaching and learning. Therefore, it is recommended that lecturers use this method in teaching, particularly for specific topics in engineering drawing that require students to master the visualization skills.

Introduction

A virtual learning environment (VLE) is a set of teaching and learning tools designed to enhance a student's learning experience by including computers in the learning process (Lloyd et al., 2009). Virtual environment in education acts as a visualization tool where students are able to visualize the problem in 3D representation form. However, students face difficulty in understanding the fundamental concept of engineering drawing where it is require the students to have high ability of visualization skills, think creatively and observe precisely (Dayana, 2013). In engineering drawing, there are many concepts students need to understand and master in before they are able to understand and solve the engineering drawing problem because by not having these ability will deter them from...
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explaining the phenomena given correctly (Mohd Safarin, 2008; Dayana, 2013; Azaman Ishar et. al., 2009). The utilization of new computer technologies as teaching courseware, in particular, graphic systems and especially those relating to three-dimensional (3D) modeling, generate a very positive contribution to improve the transmission of thoroughly correct technical information and to understand the spatial configuration in their environment. Nowadays, virtual environment courseware in education system is disperse and minimal, yet promising.

Background of Study

Visualization is a way of thinking in which images produced in the recall of the memory (Ahmad Rizal, 2009; Sorby, 2007). Among the definitions given, they include the ability of mental cutting skills, mental rotation skills, combining 2D object skills, mental development skill, mental folding skill and transformation of 3D to 2D skills to manipulate the mental images and the ability to interpret visual information in the brain (Safarin, 2009; Sorby, 2007; Contero et. al., 2005; Wiley, 1990). The problem that exists as in today whereby the lecturers face difficulties to develop student’s understanding of the dynamic learning content by using static media such as sketches on the blackboard or through printed modules (Dayana, 2013; Ashwin, 2004; Bullough, 1988). The conventional teaching approach in the learning process causes the student to face difficulties to memorize and understand back what they have failed to do so in the classroom. With the development of information technology and communication, there are changes that have been applied in the teaching method where as from the conventional teaching method to teach and learn based on electronic (Piccoli et. al., 2001; Connolly, 2005). The appropriate approach should be taken into account in order to apply the right technique in teaching engineering drawing. As an example, the virtual environment approach can be applied in order to increase student’s understanding in the concept of engineering drawing and visualization skills. This approach created by reality technology in which students are able to participate actively and directly interact with the virtual environment. Therefore, a research should be conducted to figure out how far this technology gives positive effect towards the student’s visualization skills.

Therefore, the objective of this study is to determine the effect of virtual environment courseware in teaching engineering drawing toward student’s visualization skills. This is necessary to determine the level of visualization skills among students who pursuing their study in engineering program.

Research Questions

Previous studies have shown that learning by using animation exhibits better performance than conventional learning (Ahmad Rizal, 2009; Eun-mi & Andre, 2003; Zol Bahri, 2004, Park & Hopkins, 1993, Kappe et. al., 1993; Reiber, 1989). By using multimedia as a teaching tool, it could have effect on student visualization skills and achievement in learning. (Maizam, 2002; Yuwalidi Away, 2002, Lai, 2001, Mayer, 2001; Knight, 2000). Thus, the purpose of this research was to investigate the effectiveness of using the virtual environment courseware in teaching engineering drawing. The research questions are based on the background of this study. These questions include:

1. What are the students’ levels of mental cutting skills and mental rotation skills before being exposed to the virtual environment courseware?
2. Is there any improvement of students’ level in mental cutting skills and mental rotation skills after being exposed to the virtual environment courseware?
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Conceptual framework

Figure 1 showed the conceptual framework in this study. Virtual environment courseware which contains animation and multimedia elements is seen to have a strong basic theory in order to fulfill the Atkinson-Shiffrin Memory Theory (Atkinson & Shiffrin, 1971). Using VE learning tools, it will help the teaching process in delivering information with more effectiveness compared to text. For example, pictures can be easily memorized and recognized rather than list of text. In contrast, the use of conceptual or static presentation is less effective (Paivio, 1969). Therefore, the use of multimedia and simulation environment learning in the learning process is more effective compared to other conventional teaching methods. The development of virtual environment courseware is based on the cognitive theory of multimedia derived by Mayer (2002) and ADDIE model which include analysis, design, development, implementation, and evaluation (Alutu, 2006). ADDIE instructional design model is a generic model and a systematic approach in the form of designing teaching process. This model helps to ensure effective learning outcomes are as expected by the objectives of teaching. ADDIE model consists of five phases, which are analysis, design, development, implementation and evaluation. The effectiveness of teaching engineering drawing with the virtual environment courseware is determined based on the measurement of students’ visualization skills after using virtual environment courseware. A pre-test and post-test design is used to determine the visualization skills using short version of the visualization test.

![Conceptual framework](image)

Figure 1: Conceptual framework

Study Methodology

This visualization skills study was conducted at Universiti Teknologi Malaysia, Skudai Campus. The students from Bachelor of Engineering were the respondents for this study. In order to identify the student's level in visualization skills, this study applied 2 standard visualization tests on the visualization skills and their components towards the students of engineering courses. This study consisted of pre-test and post-test where this study was conducted to make a comparison before and after the learning process. The pre-test was given to the students to obtain the level of visualization skills before undergoing treatment. Next, the respondents were given treatments which are teaching engineering drawing using virtual environment courseware. After the treatment, the respondents were asked to sit for the post-test. The instrument used for the study was adopted from the instrument called Mental Cutting Test (MCT) and Purdue Spatial Visualization Test: Rotation (PSVT: R). Paired
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samples t-test was used to determine whether there is a significant difference between mean scores of pre-test and post-test.

This study used Imsovision (Immersive Software ViSualizatION) in developing the virtual environment courseware. Imsovision is a system that supports program understanding and development through software visualization. Thus, it makes use of all the special features of such environments. For example, this system provides 3D navigation, collaborative problem solving, immersive environment and many more.

In this study, Mental Cutting Test (MCT) Purdue Spatial Visualization Test: Rotation (PSVT: R) used in this study are the standard achievement tests that have been certified by previous researchers (Scribner and Anderson, 2005; Sorby and Baartmans, 2000; Magin and Churches, 1994) which have high validity and reliability. MCT test is used to test the ability of visualize cross section of 3D object while PSVT:R is to test the ability of mentally rotate 3D object. This instrument also was go through the pilot study to test the realibility of the test . Table 1 shows the Alpha Cronbach value of the intruments used in this study.

### Table 1: Alpha Cronbach value for the research instrument

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Alpha Cronbach Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Version MCT</td>
<td>0.803</td>
</tr>
<tr>
<td>Short Version PSVT:R</td>
<td>0.802</td>
</tr>
</tbody>
</table>

### Findings

**The Skill of Visualize Cross Section of 3D Object and Mentally Rotate 3D Object among the Respondents Before and After Exposed to Virtual Environment Courseware**

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>MCT PRE - MCT POST</td>
<td>24.830</td>
<td>12.3222</td>
<td>2.2497</td>
<td>-29.4312 to 79.1037</td>
<td>-11.037</td>
<td>29</td>
<td>.000</td>
</tr>
</tbody>
</table>

Paired sample test result in table 2 showed that there was an increase MCT scores (M=24.830, SD= 12.322) among the respondents in the experimental group after they had received teaching in engineering drawing using virtual environment courseware. The increase was significant at the t (29) =-11.037, p < 0.05. The findings of the analysis show the null hypothesis is rejected as the value of p
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is smaller than the value $\alpha$ ($p = 0.00 < 0.05$). It shows that, there are significant difference in the mean score of visualize cross section of 3D object skills in the group.

**Table 3: Paired samples test for PSVT:R pre-test and post-test**

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
</table>

Paired sample test result showed that there was an increase PSVT: R scores ($M=9.000$, $SD=14.521$) among the respondents in the experimental group after they had received teaching in the engineering drawing using the virtual environment courseware. The increase was significant at the $t(29) = -3.395$, $p < 0.05$. The findings of the analysis show the null hypothesis is rejected as the value of $p$ is smaller than the value $\alpha$ ($p = 0.00 < 0.05$). It shows that, there are significant differences in the mean score of mentally rotate 3D object skills in the group.

**Figure 2: Mean score of MCT and PSVT: R pre-test and post-test**

The result in figure 2 shows that after the students have received teaching engineering drawing using the virtual environment courseware, the study found that there is an enhancement in visualization skill of engineering students. This study found that there are significant differences in skills of visualizing cross section of 3D object and mentally rotating 3D object of students who are exposed to teaching engineering drawing using the virtual environment courseware. Thus, teaching engineering drawing using the virtual environment courseware has succeeded in enhancing student’s visualization skills.
Discussions

Students who received the virtual environment courseware in teaching engineering drawing have skill of visualizing cross section of 3D object and mentally rotating 3D object higher than before they were exposed to this approach. This shows that teaching engineering drawing using the virtual environment courseware gives a positive impact to the student in improving their visualization skills especially in visualizing cross section of 3D object and mentally rotating 3D object. New and innovative approaches to using technology, including the use of various hardware and software, has shifted the paradigm and introduced nontraditional methods teaching and learning (Bertoline & Wiebe, 2005). Education using the virtual environment approach can move the user sense to be involved in the learning process. The involvements of more than one sense give positive impact in the learning process (Santangelo & Tomlinson, 2009).

According to Antonacci et al., (2008), participation in a virtual environment enables students to experience a difficult learning environment which is accessible, including operating equipment simulation, design and creating a simulation environment. Besides that, study by Metz et al. (2012) found that poor spatial-visualization skills task can directly affect perception of self-efficacy. Nowadays, virtual environment mainly consists of visual experiences, which is displayed on a computer screen or by using specific display devices but, some virtual environment includes additional sensory devices, such as speakers or headphones (Burdea & Coiffet, 2003; Abdul Rahman and Abdul Rashid, 2008). According to Rozinah (2000) and Ahmad Rizal (2009), the development of information technology in the 21st century causes the teaching and learning is not only physical occurrences such as in the classroom, but has switched to some other methods that include the virtual learning environment where teacher role is as a facilitator only during teaching and learning process.

Conclusion

The study shows that, virtual environment courseware has a positive impact in enhancing visualization skills of engineering students at Universiti Teknologi Malaysia, Skudai. The visualization skills seem to be required in engineering problem that require high visualization skills. The findings from this study support the conclusion that the virtual learning environments become one of the key factors in the delivery of education in the higher learning institutions. It is also an exposure and encouragement to the lecturer in the use of computer technology and skills competency. Thus, teaching and learning by using virtual environment courseware is one of the alternative methods to create a catalyst for productivity and quality in technical education such as engineering drawing. It is hoped that this study can be a guideline and source of inspiration for other researchers to improve the quality of teaching and learning in the education system, especially in the technical and vocational education towards a better quality of education. In conclusion, this study enables to increase the quality of education, especially technical and engineering education to the level that is prestigious and world-class standard.

References


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**Acknowledgements**

I would like to extend my gratitude to all those who are involved in this research. It is hoped that this paper will contribute to the development of engineering education research, particularly in Malaysia and among the international community in general.

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