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Impact of Blended Learning Open Source Science or Math Studies Interactive Video in the Learning of First Law of Thermodynamics

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Thermodynamics is one of the most challenging course for students as it contains many physical concepts and abstract scientific principle that were less familiar among them. Blended Learning Open Source Science or Math Studies (BLOSSOMS) approach, developed by the Massachusetts Institute of Technology (MIT) as a framework for blended learning, was used to design the lesson for teaching energy conversion in Thermodynamics. This research used quasi experimental design, where two groups of students from the Faculty of Chemical Engineering in UTM taking Thermodynamics course were investigated: a Treatment group that used the Energy Conversion BLOSSOMS video in the Thermodynamics class, and a Control group that used conventional lecture style. Students from both classes were given a pre and a post test on energy conversion concept inventory to compare their achievement in thermodynamics before and after the learning of thermodynamics in class. The collected data were analysed using SPSS version 22. Findings had shown that the video has slight effect on the students' achievement in the inventory test on Thermodynamics Energy Conversion in Generating Electricity.

1. Introduction

One of the important fundamental course for engineering students is thermodynamics. Thermodynamics is related to the physical universe and plays an important role in our lives. As a fundamental course, it has been an essential part of the global engineering curricular.

Learning thermodynamics is not an easy task, nor is teaching thermodynamics (Baher, 1998). Thermodynamics contains many abstract physical concepts that students are not familiar with, most of which are easily observed with simple experiments (Anderson et al., 2002). According to Hall et al. (2010), this course is difficult in acquiring mastery of concepts, principles, and procedures.

Students also have trouble in solving thermodynamic problems (Forbus et al., 1999). They assume that the information about thermodynamic applies only to problems studied in classes and not to a more complex and ambiguous phenomenon they encounter outside class (Lewis et al., 1993). Reardon explains that thermodynamics has a triangular structure, consisting of Principles, Processes, and Properties (Reardon, 2001). In each of these three areas, there are numerous equations. Students face difficulties in retention of knowledge when traditional teaching method is used (Huang et al., 2004).

To enhance the teaching and learning of thermodynamics, there are numerous published articles on the methods to enhance the teaching and learning in this course. Referring to Mulop et al. (2012), out of the 15 methods listed, only 2 methods do not use computer or multimedia. This shows preference towards supporting students with illustrative animations, simulations, or further explanation with visualisations when they experience complex or abstract principles that are difficult to understand (Nguyen and Khoo, 2009).

Visualisations are dynamic and cannot be achieved when knowledge is transferred through textbooks and traditional lecture environments. The applications of computer technology are needed to develop and use in the visualisations. The support of multimedia is important in assisting students.

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Blended Learning Open Source Science or Math Studies (BLOSSOMS) video on Thermodynamics Energy Conversion in Generating Electricity was designed as an approach for assisting the teaching and learning of thermodynamics, especially for engineering or physics student who has general background in energy conversion process. BLOSSOMS is seen as a possible teaching and learning approach to design lessons in abstract thermodynamics concepts to help students learn and visualise thermodynamics concepts which is difficult to be conducted in classrooms without using videos, such as illustrating real world industrial implementation of concepts. A lesson on energy conversion was designed and recorded using the BLOSSOMS framework to investigate the effectiveness of the approach in learning thermodynamics.

1.1 Research Objective

The overall aim of the research was to determine the effectiveness of using the BLOSSOMS' Thermodynamics Energy Conversion in Generating Electricity video in learning an introductory topic in thermodynamics, among engineering students. The effectiveness of the video was investigated towards the students' performance, which were measured using the following pre-post tests:

1. Among control group and treatment group.
2. Results between control and treatment group.
3. In control group.
4. In treatment group.

2. BLOSSOMS Courseware Design

2.1 Overview

Blended Learning Open Source Science and Math Studies or BLOSSOMS, is a project under Learning International Networks Consortium (LINC) of Massachusetts Institute of Technology (MIT), a global consortium of educators interested in using e-learning technologies to increase access to quality education worldwide (MIT, 2016). The video lessons are designed based on a general framework that are divided into brief segments which allows the teacher to conduct activities through active learning exercise after each segment. Each video segments contain explanation from the lecturer and an animation showing process chain which then lead to students' activity that will enhance understanding to the current topic discussed in the video. There is also a teacher's guide segment at the end of the video to assist the teachers in conducting the class utilising the video presentation.

2.2 BLOSSOMS' Thermodynamics Energy Conversion in Generating Electricity Video Segment

The video comprises of four segments, which are Segment 1: Concept of energy; Segment 2: Process of energy conversion; Segment 3: Site visit; and the last segment is Teacher's guide, which is arranged for assisting lecturers in using the video in class.

The video was designed based on the How People Learn (HPL) framework (Bransford et al., 1999). The framework asserts that there must be 4 criteria in an effective learning environment: Knowledge Centred, Learner Centred, Assessment Centred and Community Centred. Knowledge Centred means that the knowledge should be organised with interconnections around the fundamentals of the discipline, in the context of where and how it is applied in the real world. Learner Centred means that the background, preconceptions, prior knowledge and interests of the learners, are taken into account in designing the learning environment. Assessment Centred emphasise on formative assessments that allow students to get feedback on their performance, and provide opportunities for them to improve. Community Centred means that students, including instructors, help each other in the learning process to be part of a learning community.

2.2.1 Segment 1: Concept of energy

The video started with an introduction from a lecturer that guide the students throughout the video. Later on, taking the Learner and Knowledge Centred aspects into account, a scene of a shadow play, which is a form of Malaysia's heritage entertainment is shown. A group of friends were seen trying to re-enact a play using an old bicycle, a bed sheet and several self-made characters. The objective of this segment is to understand the concept of energy and its source. The concept presented here is a compilation of various forms of energy.

After the shadow play presentation, the lecturer explains the association of the shadow play performance with the energy conversion in generating electricity. The lecturer initiates the explanation with several questions that helps the students to think before she carried on the explanation. Student Activity 1 started as she asked the students to discuss with friends and teacher about the energy involved in the shadow play earlier. This activity takes into account the Assessment Centred and Community Centred aspects. After Student Activity 1, the video shows the animation of processes of shadow play as in previous segment and the chain of processes energy being converted from one form to another form.

2.2.2 Segment 2: Process of energy conversion

In this segment, the lecturer explains the forms of energy and the sources and how they are being produced. This comprehension leads them to Student Activity 2, where the objective is realising the process of energy conversion. Teacher may do any forms of activity that would allow students to connect that activity with conversion energy. There are some activities suggested to the teacher in this video to let the students discuss the energy conversion process. This activity essentially addressed all the four criteria of the HPL framework.

2.2.3 Segment 3: Site visit

Segment 3 reviews the chain of energy conversion processes to generate electricity. The lecturer reviews the conversion processes that occur in the previous experiment done by the students and explain briefly on amount of energy that will be discussed in the next video. For Student Activity 3, lecturer should get students to present the chain of processes to assess their understanding of the concept and provide feedback, as stated in the Assessment Centred criterion of the HPL. Students are encouraged to identify the energy being converted, its processes and what are needed for the process to occur.

Later, the video shows a visit to power station to provide students the connection between concepts learned to real industrial application, in accordance with the Knowledge Centred aspect. At the power station, an engineer introduces and explains about the plant operations and the process of generating electricity, from generator to other systems. Animation of the process chain is then presented to support the engineer's explanation.

After that the lecturer add some points in the video before the students are left with questions by the lecturer which led them to Student Activity 4. In this activity, students would be given a demonstration and they would have to discuss with friends on related current issues. At the end of this segment of the video, the lecturer summarises the whole processes in thermodynamics energy conversion in generating electricity and leave the students with questions to think of as future engineers.

3. Method

The research was designed based on quasi experimental and were carried out to identify the effectiveness of the blended learning using BLOSSOMS video towards students learning process. Data were collected using a concept inventory on energy conversion.

There are two groups of sample participants, namely the treatment group and the control group. Both are first year UTM chemical engineering students. The treatment class consists of 25 students. This class used BLOSSOMS' Thermodynamics Energy Conversion in Generating Electricity video and was taught by a relatively new lecturer who had undergone student centred learning courses and skilled in conducting active learning. While the control class has 27 students, and was taught by an experienced lecturer who is also well known as a good lecturer. The mode of delivery is mainly lectures, interspersed with questions and anecdotes.

The energy conversion concept inventory test was distributed to all students before the teaching and learning to obtain the pre-test data. After the teaching and learning took place, the same questions were distributed to the students for the post-test data. The collected data from the tests were then analysed using SPSS version 22.

4. Results

There were 27 sets of data collected from the control group and 16 sets of data collected from the treatment group. Even though there were 25 students in the treatment class, only 16 sets of completed data were collected. The scores were recorded and the increment between pre-test and post-test scores were extracted from the results. The percentage of the average scores of each pre and post test scores as well as the learning gains for control and treatment class were illustrated in Table 1.

Table 1: Pre-test scores, post-test scores, and learning gains for control class and treatment class

	Control	Treatment
Pre-test score (%)	38.89	37.05
Post-test score (%)	60.05	69.64
Learning gain (%)	21.16	32.59

The students in both classes were asked to answer an inventory test at the beginning of the class before the lecture starts. It was found that the students in control class achieved higher scores than the students in treatment class in the pre-test by 1.8 %. After the class ends, the students were asked to answer the concept

test once again. The difference is that the students in treatment class went through a lesson using the Energy Conversion BLOSSOMS video during the lecture. It turned out that the students in treatment class score higher than the students in control class by 9.6 %. This makes the learning gain of students in treatment class higher than the learning gain of students in control class by 11.4 %.
Table 2 shows the results analysis of descriptive statistic. Graph of descriptive statistics for pre-test and post-test in control and treatment conditions showing mean score is presented in Figure 1.

Table 2: Mean score and standard deviation for Control class and Treatment class

Group	Control		Treatment	
Number of students (N)	27		16	
Test	Pre	Post	Pre	Post
Mean (M)	5.44	8.41	5.19	9.75
Standard deviation (SD)	2.74	2.76	3.53	2.05

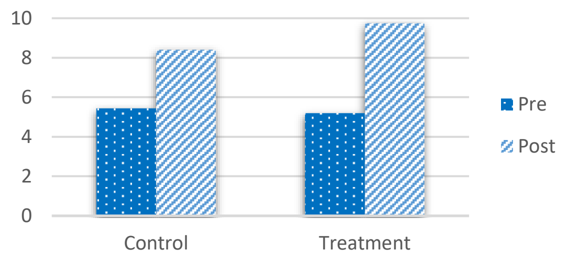

Figure 1: Mean for pre-test and post-test in control and treatment conditions

The figure shows an improvement in terms of students' performance from the pre-test to the post-test in both classes with a larger improvement is seen in treatment class. This shows that the support from the BLOSSOMS video could enhance the students' performance in the learning of Thermodynamics.

4.1 Students' achievement in inventory test in pre-test and post-test mean score between Control class and Treatment class

The investigation on the performance is expanded to the mean score of the students' achievement in pre-test and post-test mean score between control class and treatment class. Independent sample t-test on students' achievement between treatment class and control class for pre-test score and post-test score are shown in Table 3 and Table .

Table 3: Independent sample t-test on students' achievement in inventory pre-test score in control class and treatment class

Group	N	M	SD	t	df	p
Control	27	5.44	2.74	0.267	41	0.791
Treatment	16	5.19	3.53			

Independent sample t-test on pre-test scores in Table 3 was conducted to strengthen the results from mean score analysis in Table 2. From the t-test, it was found that there was no significance for control class (M = 5.44, SD = 2.74) and treatment class (M = 5.19, SD = 3.53) with conditions; t(41) = 0.267, p = 0.791. With related to the mean score of both classes, the results suggest that the students in control group has score slightly higher than the students in treatment group in their pre-test. This supports that the students in control group has more initial knowledge in Thermodynamics Energy Conversion than the students in treatment group before the class has started.

Table 4: Independent sample t-test on students' achievement in inventory post-test score in control class and treatment class

Group	N	M	SD	t	df	p
Control	27	8.41	2.76	1.685	41	0.100
Treatment	16	9.75	2.05			

The t-test result on post-test score shown in Table 4 also demonstrates that there was no significance for control class (M = 8.41, SD = 2.76) and treatment class (M = 9.75, SD = 2.05) with conditions; t(41) = 1.685, p = 0.100. These results suggest that the BLOSSOMS interactive video on Thermodynamics Energy Conversion in Generating Electricity does not have effect on the post-test score among students. Specifically, the results suggest that the scores of students in the class that underwent the lesson using the Energy Conversion BLOSSOMS interactive video is not significantly different than the students who went through lectures in the control group.

Table 5 and 6 shows the results of paired sample t-test of the inventory pre-test and post-test scores for control class and treatment class.

Table 5: Paired sample statistics

Group	M	N	SD	
Pair 1	Control Pre-test	5.44	27	2.74
	Control Post-test	8.41	27	2.76
Pair 2	Treatment pre-test	5.19	16	3.53
	Treatment post-test	9.75	16	2.05

Table 6: Paired sample t-test on pre-test and post-test scores of students in control class and treatment class

Group	M	SD	t	df	p	
Pair 1	Control Pre-test – Post-test	-2.96	1.95	-7.891	26	0.000
Pair 2	Treatment pre-test – post-test	-4.56	2.63	-6.93	15	0.000

For control group, it was found that there was a significant difference in the scores for pre-test (M = 5.44, SD = 2.74) and post-test (M = 8.41, SD = 2.77) conditions; t(26) = -7.89, p = 0.000). The results suggest that the students' achievements in inventory test score has increase even without BLOSSOMS interactive video. While for treatment group, it was found that there was a significant difference in the scores for pre-test (M = 5.19, SD = 3.53 and post-test (M = 9.75, SD = 2.05) conditions; t(15) = -6.93, p = 0.000). The results suggest that the students' achievements in inventory test score has increase with BLOSSOMS interactive video. In a meantime, note that the students' achievements in inventory test score in control class has also increase even without the video.

4.2 Incremental Scores between Pre-test and Post-test

The test increment scores of each student in the treatment class and the control class were also analysed. This is the difference in the post-test scores from the pre-test scores of each student in the two groups. An independent sample t-test was conducted to compare the incremental scores of students in control class and treatment class, as shown in Table 7.

Table 7: Independent sample t-test on incremental scores of students in control class and treatment class

Group	N	M	SD	t	df	p
Control	27	2.96	1.95	2.28	41	0.045
Treatment	16	4.56	2.63			

It was found that there was a significant difference in the scores for treatment class (M = 4.56, SD = 2.63) and control class (M = 2.96, SD = 1.95) conditions; t(41) = 2.28, p = 0.045). These results suggest that the Energy Conversion Blossoms interactive video does have effect on the incremental score on the inventory test among students. Specifically, the results suggest that the utilisation of the Energy Conversion BLOSSOMS interactive video in the treatment class does increase the students' achievement in Thermodynamics Energy Conversion.

5. Discussion

The impact of using BLOSSOMS video in engineering classroom on students' learning can be perceived through the results of t-test on the students' understanding as measured through the energy conversion concept inventory pre-test and post-test score for treatment class. It was found that there was a significant difference in the scores for pre-test and post-test, with conditions p = 0.000. In a meantime, the students' achievements in inventory test score of control class who used traditional lecture has also increase even without BLOSSOMS interactive video. By looking at the learning gain of the students, it was found that there was a slight significant difference in the scores for treatment class and control class with p = 0.045. The results suggest that the video does have slight effect on the score incremental of the inventory test among students.

By looking at the results of t-test in the incremental score of students in the control class and the treatment class, it was found that there was a slightly higher increase in the scores increment of treatment class compared to control class with $p = 0.045$. In terms of percentage, learning gains in treatment class (32.59 %) is also higher than that in control class (21.16 %). This suggests that the use of BLOSSOMS interactive video in an engineering classroom gives a higher impact on students' learning.

Using the Energy Conversion BLOSSOMS video does increase the students' performance compared to the control class, although the lecturer in the control class is deemed to be a good lecturer for the course. Students' performance in this context can be referred to the students' gain in inventory test. Quantitatively, it can be obtained from the scores incremental between pre-test and post-test. It was found that there was a slightly significant difference in the scores for treatment class and control class with $p = 0.045$. The percentage of learning gains in treatment class (32.59 %) is also higher than that in control class (21.16 %). This would suggest that BLOSSOMS interactive video does increase the students' performance.

This is consistent with previous research on problems faced by students in the learning of thermodynamics by Bullen and Russell (2007) where the use of blended learning courseware could support students in learning Thermodynamics.

6. Conclusion

The findings of the study found that using BLOSSOMS video in the teaching and learning thermodynamics gives good impact to the students in terms of the effectiveness of the video. Therefore, utilising BLOSSOMS video in teaching Thermodynamics can be an interactive approach of teaching using technology environment.

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