The Effectiveness of Simulation as a Learning Media for Mechatronics Engineering Subjects

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Abstract

Conventional ways of teaching Mechanical or Mechatronics Engineering subjects are no longer relevant. Students need to be exposed with real-life apparatus to increase the awareness and understand more on the engineering concepts. Nevertheless, the lacking of these equipments, partly due to its size, cost and space, has hardened the learning process. Therefore, suitable teaching aids can be used to ensure students' comprehension between theory and reality part. Simulation-based approach can be performed in order to tackle the problem. Hence, this research is conducted to study and recognize the usage of learning module based on multimedia in education of Mechatronics Engineering subjects. In this research, education software/ courseware of animation-based simulation has been developed as a teaching and learning aid and used as the learning approach. The main objective of this research is to study the efficiency of animation-based simulation towards Mechatronics Engineering students for Pneumatics System subject. The aim was to identify whether there is significant difference existed in overall achievement compared to the conventional method of learning. Results obtained have proved the effectiveness of this approach due to the increment of score in students' performance test.

Keywords: *Animation-based Simulation, Mechatronics Engineering, Learning Achievement, Pneumatics System*

1. Introduction

Learning is a life-time process. In Surah Al-Alaq, verses 1-5, Allah s.w.t. reminds us about the importance of education and encourages human being to explore new discovery in education [1]. Hence, this research is being conducted to explore new technique in teaching and learning engineering subjects. Different approaches of learning are needed to suit various backgrounds of engineering areas. Some require more calculations, whereas others may concentrate on practical and in-depth attention [3] especially for physically invisible element like the movements of components inside an apparatus.

The scenario of education researches in Malaysia showed only a few relevant studies havebeen conducted to overcome this situation. Due to its importance, the aim of this research is to improve teaching and learning process [4] so that students will get the right engineering concepts and skills, and be able to perform the tasks efficiently [2]. Here, the method of learning would be concentrating on Mechatronics Engineering subjects, which is also applicable to other field of similar background of engineering as well.

The engineering education situation shows the existence of a step-by-step process of learning, which begins with the explosions towards the theory of the subject. Then, students need to perform practical tasks in the laboratory [4] or workshop to understand more on the concepts [2]. However, the shortage of suitable devices for teaching aids and unsuitable approach of teaching [2] contributed towards the problem for students to understand the engineering concepts. This has been proved by previous researches [3 and 7] where the problems of Mechatronics Engineering education through lecture occur due to unsuitable teaching aids or approach.

Most of the contents of Mechanical or Mechatronics Engineering subjects consist of theories about moving components [3]. Hence, explanation about these components should be included with demonstration or use suitable teaching aids [3 and 8] to

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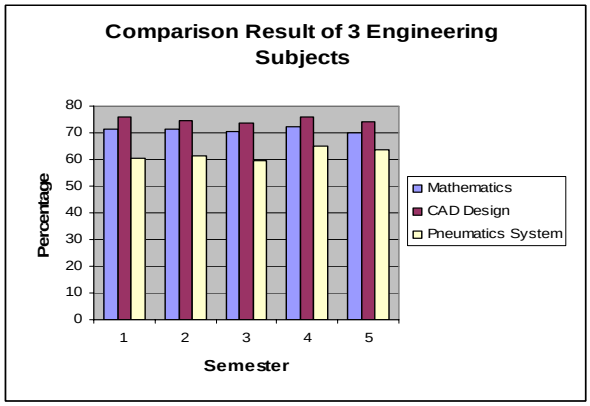
make sure students can observe the relationship between theory and reality.

In this research, the Pneumatics System subject is being selected as the experimental medium. This subject is one of the curriculums available for Diploma of Mechatronics Engineering [2]. An interactive self-learning approach using animation-based learning software / courseware is being developed. The reason of selecting *Animation-based Simulation Courseware* (ABSC) method is due to its reputation based on past researches [9, 12 and 13] and its results showed the significant increment of students' achievement. The selection of this subject is due to its difficulties in explaining the theoretical and practical aspect. Due to its widely usage especially in automation and robotic-based industries, therefore students need to concentrate and understand this subject. Without suitable teaching aids, students would face problems in understanding the concepts of components involved.

2. Comparison of Students Result

A case study in Ungku Omar Polytechnic was conducted, in order to clarify the learning difficulty of engineering subjects further. The examination results data was sourced by Examination Unit. The data collection is for Third Year Diploma of Mechatronics Engineering students ranging from June and December semesters of year 2002, 2003 and 2004.

Graph 1: Comparing Result of Three Engineering Subjects



According to **Graph 1,** the averages of student achievement for engineering subjects are lower than technical drawing (CAD Design) or subjects which involve calculation. This result is similar to other engineering subjects that need detail description of components. This phenomenon is one of the learning difficulty facing polytechnic institutes in Malaysia. This paper is a proposal to develop a courseware in order to fulfill the need of teaching and learning enhancement of Pneumatics System subjects.

3. Research Objectives

The objective of this study is to develop an *Animation-based Simulation* by its definition, designation and testing. Pneumatics System subject will be used as the topic for efficiency testing of this approach. From here, the efficiency of using this method through multimedia animation elements on learning Pneumatics System is being studied. Students' performance before and after the implementation of this method are recorded and any results of significant difference are studied. From here, the impact of using the learning materials can be recognized.

4. Design of Animation-Based Simulation Courseware

In the context of the design of *Animation-based Simulation Courseware* (ABSC) as a learning material, interactive multimedia covers response, metacognition, integrated learning, strategy, exploration with hypertexts, and screen design [9], categorised as prescriptive, democratic and cybernetic [11]. Animation elements which are interactive multimedia characteristics are the foundation of the ABSC design, exactly right referring to previous research showed the effectiveness of interactive multimedia as one of learning platform [10].

Technical aspect of the screen design focused on observation and concentration, develop and maintain the interest, develop the deeper learning process, develop integration and navigation crossing education [4], constitute the main contributor to deliver information. The designation of the ABSC was done by referring the Instructional Design System Approach model [10]. Basically, the model involves 9 fundamental components and teaching steps revision. Improvement has been done on the 7th component process by using Instructional System Design [6] model which has ten steps of systematic development of ABSC as shown below;

1. Identification of objective.
2. Collection of sources.
3. Learn the teaching contents.
4. Brainstorming of teaching idea
5. Structuring teaching style.
6. Development of subject flow chart.
7. Mind mapping on paper.
8. Strategize the subject
9. Supplying teaching aids.
10. Evaluation and revision.

ABSC is developed using Macromedia Authorware software with assistance from other software, such as Windows-based tools like Flash, ToolBooks, Visual Graphic, etc. Its presentation includes some interesting graphics and animations show of movements of various components and circuits of electro-pneumatics system, together with messages feature that could assist students in exploring the content of this simulation software [11 and 12].

The content of electro-pneumatics subject that has been developed in this ABSC simulation software are as follows:

1. Introduction to Electro-pneumatics system.
2. Actuator components.
3. Processor components.
4. Pneumatics circuits.
5. Electrical circuits.
6. Electro-pneumatics system design.

Self-paced learning using ABSC as shown in the example screen appearance (Figures 1, 2 and 3) could help students in conquering electrical and pneumatics circuit's integration in its sequence. The animated simulation appearance could show in detail the type of movement occuring inside the actuator, processor as well as other devices. To strengthen students' knowledge and skills, a tutorial display is also being prepared. The tutorial is a solution-based preparation, where students are being asked to solve the given problems using the most optimum system as the solution. Students are free to choose the design to solve the problems through input and output screen. Every single problem can be solved using various methods, but the best solution is through designing a circuit using a minimum number of components.

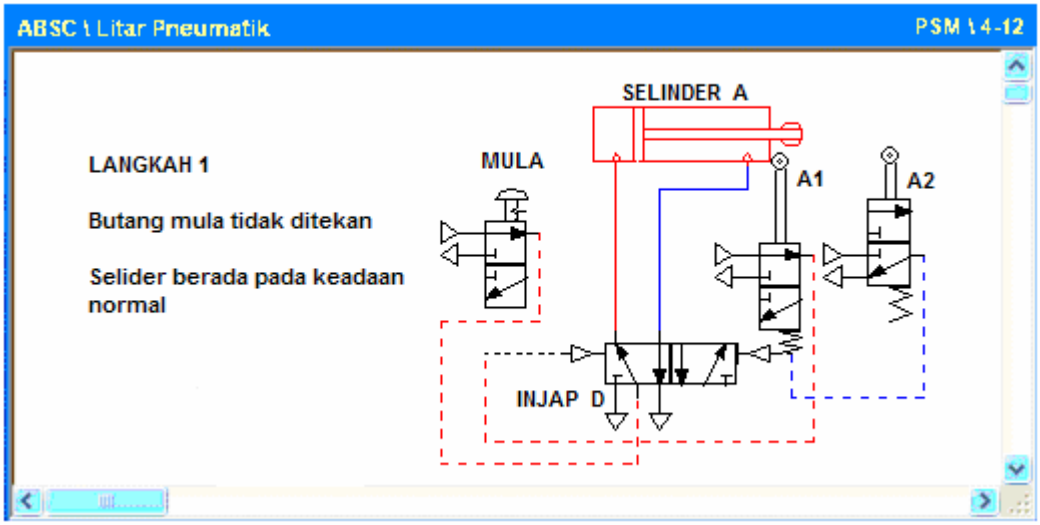


Figure 1: Example of animated simulation activity display screen

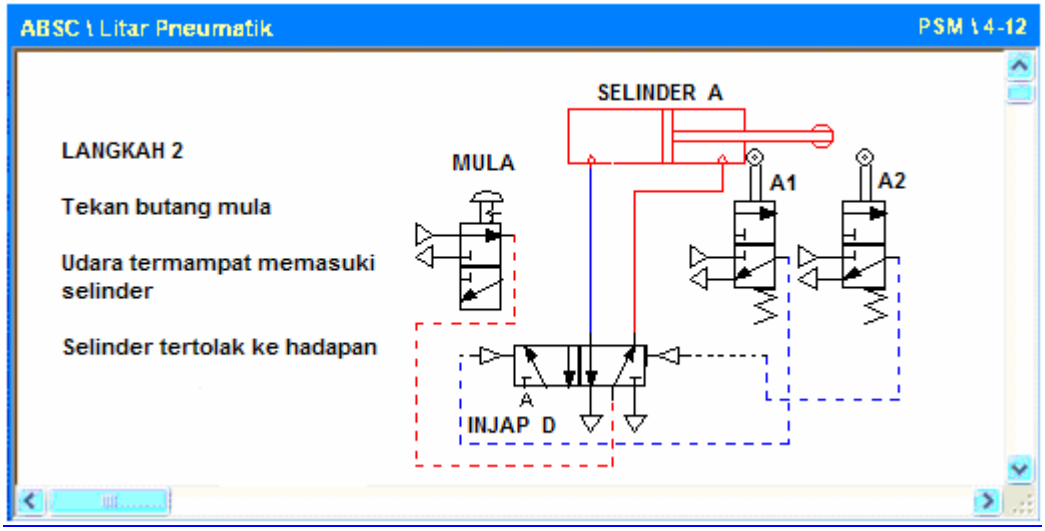


Figure 2: Example of animated simulation activity display screen

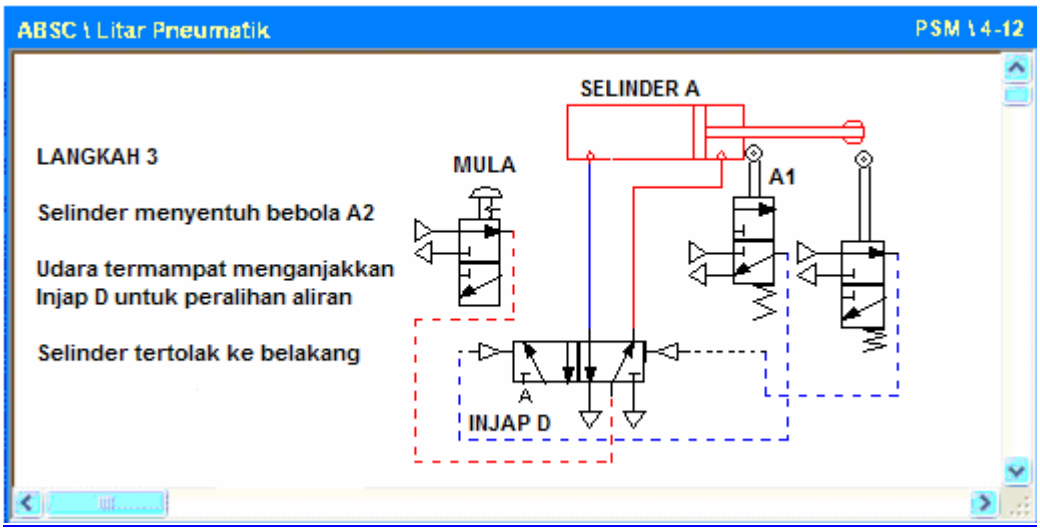


Figure 3: Example of animated simulation activity display screen

5. Research Methodology

The implemented research procedures are based on the design of the pretest-posttest control group. The experiment design is as follows:

R----G----O1----X ----O2

R -- distribution of sample by random
G -- sample group
O1 -- pre test
X -- treatment by conventional / ABSC
O2 -- post test

To perform this research, a study on 97 randomly chosen students was carried out as the sample. The population is from the Semester 5 students of Diploma of Mechatronics Engineering course. The involved samples were bring exposed with Pneumatics System subject theoretically before they were given some further exposure and pre-test, to ensure the equality of basic learning. Next, a group of students are seated for normal lecture, and another group of samples would be given the chance to obtain self learning by using ABSC. They were free to use their own time within a specific frame before the post-test is being conducted.

6. Results Analysis

The results for the pre and post-tests of this research were analysis by SPSS software. The description of the result is shown in Graph 2 and Tables 1 to 3. The average overall achievement of students by conventional lecture of Pneumatics System subject for June and December semesters of year 2002, 2003 and 2004 is as shown in Graph 2. It was found that the mean result of subjective test after treatment is 72.42% as in Table 1, which is greater than the previous result. The comparison showed that the student obtained better results by using ABSC as a learning tool.

Graph 2: Students average result for Pneumatics System.

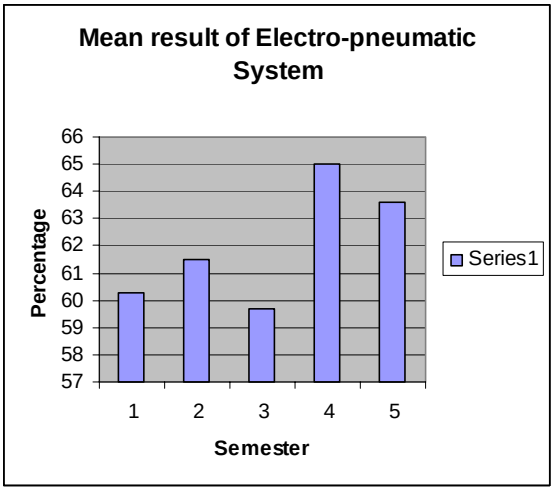


Table 1. The value of minimum, maximum, mean and standard deviation for subjective test

Test	N	Minimum	Maximum	Mean	Standard deviation
Subjective test	97	54	88	72.42	6.01

Table 2. T-test - the value of minimum, maximum, mean and standard deviation

Method	Test	N	Minimum	Maximum	Mean	Standard deviation
1	Pre test	41	7	15	12.32	1.56
2		52	5	14	13.48	1.23
1	Post test	41	13	20	18.20	1.27
2		52	10	19	18.69	1.00
1	Achievements	41	4	7	5.83	1.16
2		52	5	10	5.21	0.91

(p = <0.05) (Method = 1 - ABSC; 2 - Conventional lecture)

Table 3. T-test - difference of marks mean increment for pre-test, post-test and achievements.

Method	Variables	N	Mean	Standard deviation	Value of - t	Degree of Freedom	Significance level
1	Pre test	41	12.32	1.56	-4.031	91	0.000*
2		52	13.48	1.23			
1	Post test	41	18.20	1.27	-2.113	91	0.037*
2		52	18.69	1.00			
1	Achievement	41	5.83	1.16	2.872	91	0.005*
2		52	5.21	0.91			

(p = <0.05) (Method = 1 - ABSC; 2 - Conventional lecture)

Using the analysis of variant (ANOVA) for the data of method 1 students, the pre test data was compared with the post test data. It was found that the mean of the post test is greater than that of the pre test (Table 2). This has proven the usage of ABSC as a tool in helping students obtained better results. Table 3 shows that the mean for student overall achievements for method 1 students is higher than method 2 students, with the significance difference (p=<0.01). This demonstrate the existence of significance difference for overall achievement method 1 students compared to method 2 students (post test score – pre test score).

7. Conclusion

The research showed that there are significant differences in students' score after using ABSC. This is due to the developed simulation software design which has exploited the animation elements and interactive multimedia, where it has increase the effectiveness of learning and solving of related problems. It can be concluded that the usage of ABSC has helped students in understanding the concept of Pneumatics System better and obtained higher achievement compared to the conventional method.

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