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Developing Digital Simulation for Mechanical Engineering: An Innovation in Distance Education

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Abstract

Distance education engineering students need to be exposed to real-life apparatus to increase the awareness and understanding of the engineering concepts. Nevertheless, the lacking of these equipments, partly due to its size, cost and space, has constained the distance learning process. Therefore, suitable teaching aids can be used to ensure students' comprehension between theory and reality. Digital simulation-based approaches can be implemented. This research is conducted to study and recognise the usage of distance learning module based on multimedia in engineering subjects. Software or courseware of animation-based simulation developed as a distance teaching and learning aid was used as the learning approach. The objective of this research is to study the efficiency of animation-based simulation towards Mechanical Engineering students for Pneumatics System subject. The aim was to identify whether there exist a significant difference in the overall achievement compared to the conventional method of learning. Results obtained have proven the effectiveness of this approach due to the increment of score in students' performance test.

Abstrak

Para pelajar kejuruteraan pendidikan jarak jauh perlu didedahkan kepada peralatan sebenar untuk menambahkan kesedaran dan kefahaman konsep-konsep kejuruteraan. Namun, kekurangan peralatan-peralatan tersebut, sebahagiannya disebabkan saiz, ruang dan harga, telah menjadi kekangan kepada proses pembelajaran jarak jauh. Oleh itu, alat bantu mengajar yang sesuai dapat digunakan untuk menentukan kefahaman teori dan realiti pelajar. Pendekatan digital berasaskan simulasi dapat dilaksanakan. Kajian ini dijalankan bagi mengkaji dan mengenal pasti kegunaan modul pembelajaran jarak jauh berdasarkan multimedia dalam subjek-subjek kejuruteraan. Sofwer atau perisian kandungan bagi simulasi berasaskan animasi yang dikembangkan sebagai bantuan pengajaran dan pembelajaran jarak jauh telah digunakan sebagai pendekatan pembelajaran. Objektif penyelidikan ini ialah untuk

mengkaji keberkesanan simulasi berasaskan animasi terhadap para pelajar kejuruteraan Mekanik bagi subjek Sistem Pneumatik. Tujuan kajian ialah untuk mengenal pasti sama ada terdapat perbezaan signifikan di dalam pencapaian keseluruhan berbanding kaedah pengajaran konvensional. Dapatan kajian membuktikan keberkesanan pendekatan ini berdasarkan penambahan markah pencapaian ujian para pelajar.

Introduction

The scenario of education researches in Malaysia showed only a few relevant studies has been conducted to overcome this situation. Due to its importance, the aim of this research is to improve teaching and learning process (Charles & Marc, 1995) so that students will get the right engineering concepts and skills, and be able to perform the tasks efficiently (Martin & Matts, 2005). Here, the method of learning would be concentrated on Mechatronics Engineering subjects, which is also applicable to other field of similar background in engineering.

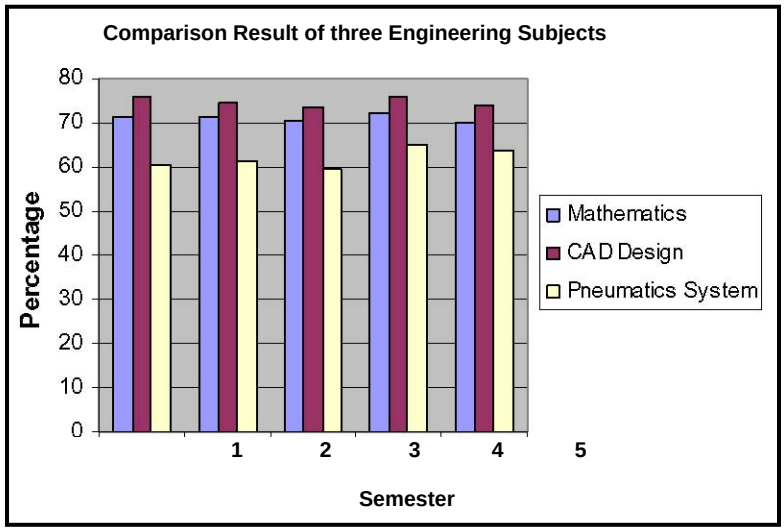
The engineering educational transaction shows the existence of a step-by-step process of learning, which begins with the explosions towards the theory of the subject. Then, students need to perform practical tasks in the laboratory (Charles & Marc, 1995) or workshop to understand more on the concepts (Martin & Mats, 2005). However, the shortage of suitable devices for teaching aids and unsuitable approach of teaching (Martin & Mats, 2005) has contributed towards the problem for students to understand the engineering concepts. This has been proved by previous researches (Sergey, 2002) and (Eigen & Komoski, 1989) where the problems of Mechanical Engineering education through lecture occur due to unsuitable teaching aids or approaches. Most of the contents of the Mechanical or Mechatronics Engineering subjects consist of theories about moving components (Sergey, 2002). Hence, explanation about these components should be included with demonstration or the use suitable teaching aids (Sergey, 2002) and (Entwilse, 1989) to make sure students can observe the relationship between theory and reality.

In this research, the Pneumatics System subject was selected as medium. This subject is available for Diploma of Mechatronics Engineering (Martin & Mats, 2005). An interactive self-learning approach using

animation-based learning software/courseware was developed. The reason of selecting an Animation-based Simulation Courseware (ABSC) method is due to its reputation based on past researches (Zol Bahri Razali, 1999, Ng W.K. & Rozinah Jamaluddin, 1997) 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, the students need to concentrate and understand this subject. Without suitable teaching aids, students would face problems in understanding the concepts of components involved.

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 via the Examination Unit. The data collection was for the Third Year Diploma of Mechatronics Engineering students ranging from June and December semester of year 2002, 2003 and 2004.



Graph 1 Comparing Result of Three Engineering Subjects

According to Graph 1, the average of student's achievement for engineering subjects are lower than the technical drawing (CAD Design)

or subjects which involve calculation. This result also applies to other engineering subjects that need a detailed description of components. This phenomenon is one of the learning difficulties faced by polytechnic institutes in Malaysia. This paper serves as a proposal to develop a courseware in order to fulfill the needs of teaching and learning enhancement of Pneumatics System subjects.

Research Objectives

The objectives 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. Then, the efficiency of using this method through multimedia animation elements on learning Pneumatics System was studied. Students performance before and after the implementation of this method was recorded and any results of significant difference was recorded.

Design of Animation-Based Simulation Courseware

From the design of Animation-based Simulation Courseware (ABSC) as a learning material, interactive multimedia characteristics covers response, metacognition, integrated learning, strategy, exploration with hypertexts, and screen design, categorised as prescriptive, democratic and cybernetic (Chapman, 1993). Animation elements which is interactive multimedia characteristic is the foundation of the ABSC design, and reference to previous research showed the effectiveness of interactive multimedia as one of learning platform (Dick & Carey, 1996).

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 (Charles & Marc, 1995), constitute the main contributor to the delivery of information. The design of the ABSC was done by referring to the Instructional Design System Approach model (Dick & Carey, 1996). 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 (Trollip & Alessi, 1988) 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. Strategise the subject.
9. Supplying teaching aids.
10. Evaluation and revision.

ABSC was developed using Macromedia Authorware software with the assistance from other softwares, 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 (Chapman, 1993 & Ng, 1997).

The content of electro-pneumatics subject was 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-pace learning using ABSC as shown in the example screen capture (Figure 1) 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 occured inside the actuator, processor as well as other devices.

To strengthen the students' knowledge and skills, a tutorial display is also being prepared as example in Figure 2, 3 and 4. 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.

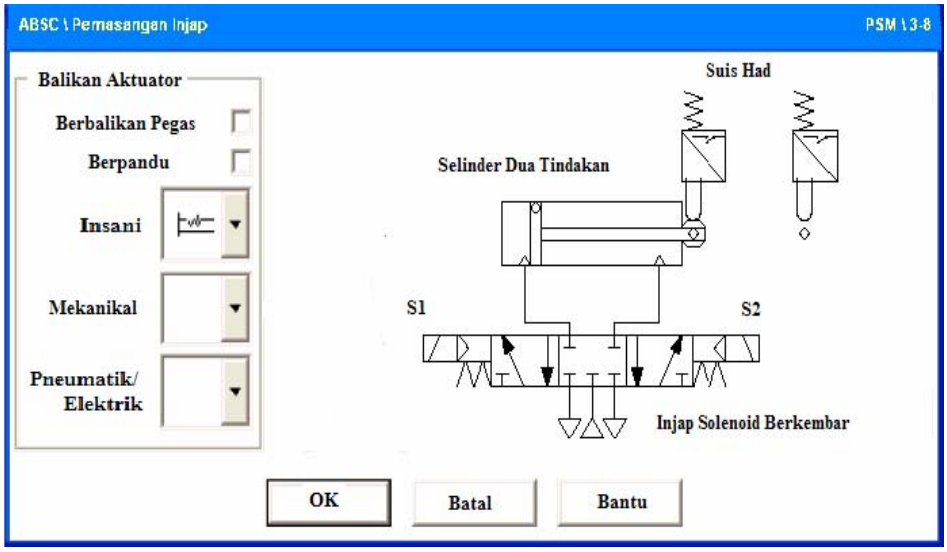


Figure 1 Example of animated simulation-based tutorial display screen

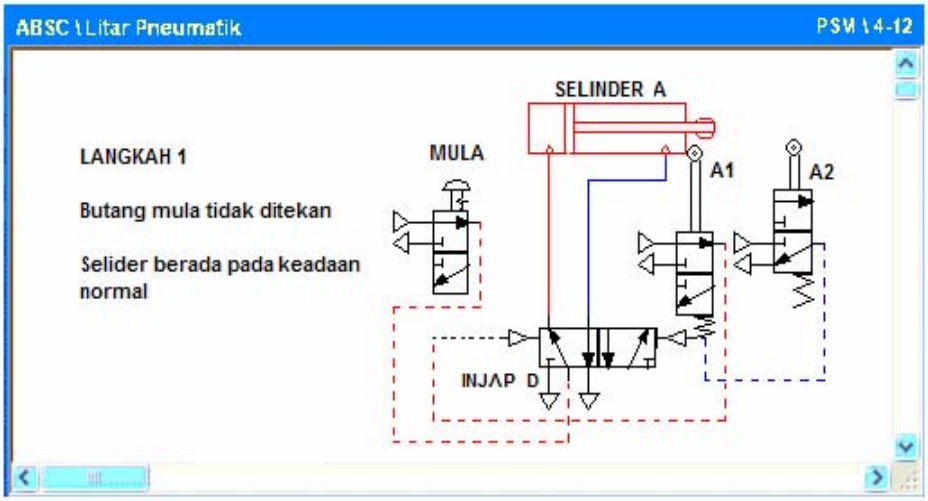


Figure 2 Example of animated simulation activity display screen

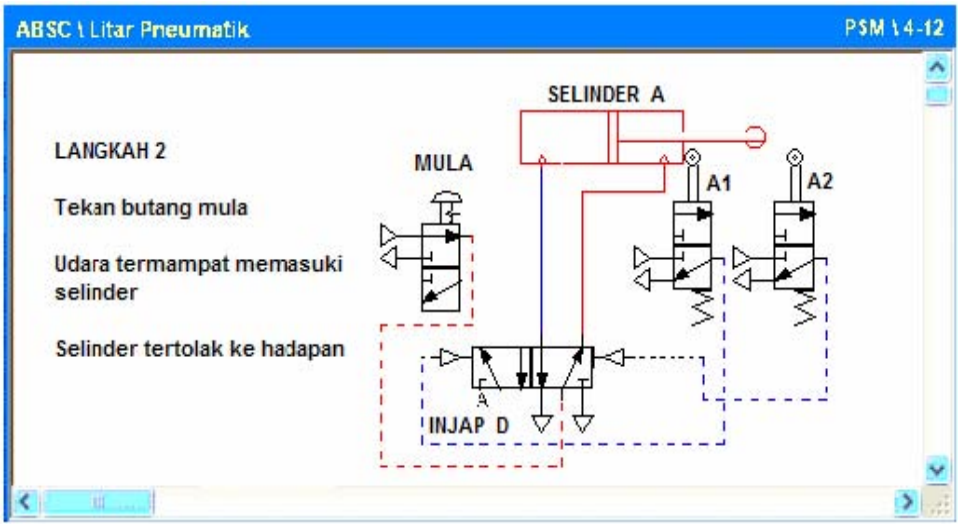


Figure 3 Example of animated simulation activity display screen

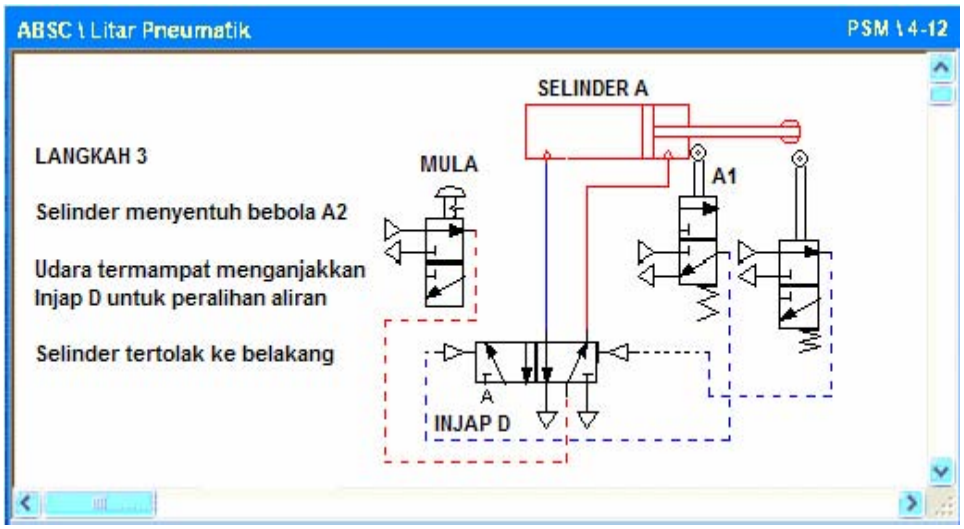


Figure 4 Example of animated simulation activity display screen

Research Methodology

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

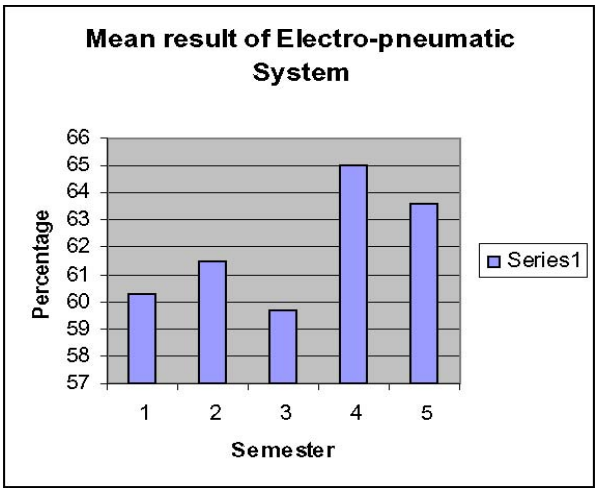
$$\mathbf{R — G — O_1 — X — O_2}$$

R – distribution of sample by random
G – sample group
O_1 – pre test
X – treatment by conventional lecture or ABSC
O_2 – post test

To conduct this research, a study on 97 randomly chosen students was carried out as the sample. The population are from the Semester 5 students of the 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. Then, a group of students will seat for normal lecture, and another group of samples would be given the chance to undergo self learning by using ABSC. They were free to use their own time within a specific frame before the post-test is being conducted.

Results Analysis

The result for pre and post-test of this research were analysis by SPSS software. The description of the result as stated and shown in graph and tables below. As comparison to overall achievement by conventional lecture of Pneumatics System subject for June and December semester of year 2002, 2003 and 2004 have been studied and revised, as shown in Graph 2. From the description of analysis, the mean result of subjective test after treatment was 72.42% as shown in Table 1.



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

By the description analysis and analysis of variant (ANOVA) for the data using method 1, the pre test data was compared with the post test data; it was found that the mean of the post test is greater than pre test (Table 2). This proves the usage of ABSC as the tools has helped students to obtain better results.

Result from this research, as in Table 3, shows that the mean for student overall achievements for method 1 students is higher than method 2 students, with the significant 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).

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

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			

Conclusion

Results obtained from this research showed that there are significant difference istudents' score after using ABSC. This increment is due to the developed simulation software design which has exploits the animation elements and interactive multimedia, where it has increase the effectiveness of learning and solving the related problems. Overall, the usage of ABSC has helped students in understanding the concept of Pneumatics System and obtained higher achievement compared to the conventional method.

References

Chapman, W. (1993). Color Coding and the interactivity of Multimedia. *Journal of Educational Multimedia and Hypermedia*, *2*, pp. 3-23.

Charles, U. & Marc, T. (1995). Mechatronics instruction in the Mechanical Engineering curriculum at Georgia Tech, *Mechatronics*, *5*(7), pp. 723-741.

Dick, W. & Carey, L. (1996). The Systematic Design of Instruction, (3rd. ed.). New York: Harper Collins.

Eigen, L.D. & Komoski, P.K. (1989). Research Summary Number 1. ERIC Document Reproduction Service No. ED001 386.

Entwilse, D.R. (1989). Four Studies involving the used of programed materials in engineering education. ERIC Document Reproduction Service No. ED003 195.

Fraser, C.J., Milne, J.S. & Logan, G.M. (1993). An educational perspective on applied Mechatronics. *Mechatronics*, *3*(1), pp. 49-57.

Martin, G. & Mats, H. (2005). Mechatronics – the evolution of an academic discipline in engineering education, *Mechatronics*, *15*(2), pp. 179-192.

Ng, W.K. (1997). Multimedia Research and Training in Universiti Sains Malaysia – a need for a smart connection. Proceeding Papers at Conference of 'Discovery Malaysia 97' (Shah Alam, 3-5 June, 1997).

Rozinah Jamaluddin (1997). Teaching and learning using Multimedia Software. Proceeding Papers at Conference of 'Discovery Malaysia 97' (Shah Alam, 3-5 June,1997).

Sergey E.L. (2002). Mechatronics curriculum – retrospect and prospect, *Mechatronics*, *12*(2), pp. 195-205.

Trollip, S.R. & Alessi, S.M. (1988). Incorporating Computers Effectively into Classroom. *Journal of Research in Computing in Education*, *21*(1), pp. 70-81.

Zol Bahri Razali. (1999). The effect of using Multimedia Based Animation in the learning of Electro-pneumatic's topic. Master's thesis. Unpublished.