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Effectiveness of Multi-Frames Video Recorded Experiments on Pre-University Students' Achievement for Capacitor Topic

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Abstract

The aim of this study is to determine the effectiveness of multi-frames video recorded experiments (MFVREs) on pre-university students' achievement for capacitor topic. This study was carried out among 60 Diploma Science students of Universiti Pendidikan Sultan Idris, Malaysia. Students' pre-test and post-test scores were analyzed using independent sample t-test. The effectiveness of MFVREs on students' achievement were analyzed for four subtopics of capacitor: basic concept of capacitor (S1), series connection of capacitors (S2), parallel connection of capacitors (S3) and combination of series and parallel connection of capacitors (S4). Findings revealed that MFVREs give significant effects on students' achievement for S2, S3 and S4 subtopics but no significant effect to students' achievement for S1 subtopic compared to PowerPoint slides. Thus, MFVREs approach can be used either as a teaching aid in normal classroom or a student-centered learning video in order to improve the achievement of pre-university students for physics subject.

Keywords Multi-frames video recorded experiments (MFVREs); capacitor; pre-university students, achievement

INTRODUCTION

Experiment is an important element in teaching and learning (T&L) session of science subject. It is used to investigate a phenomenon that occurs in everyday life in the controlled environment using the scientific investigation methods. Thus, experimental results will be used as evidence to reinforce the theory and eliminate misconceptions among students [1, 2]. However, there are some students did not conduct some experiments in the course syllabus probably due to time constraints, lack of special equipments and the safety issues [3, 4, 5]. Thus, students are taught by conventional teaching method but it could not attract students' attention to learn the subject and their misconception could not be eliminated.

Since educational teaching technology should keep in phase with the latest development of the information and communication technology (ICT), all researchers around the world would integrate the use of ICT in T&L session to solve the above mentioned problems. Previous studies conducted by [6, 7] proved that the microcomputer based laboratory gave the same impact as the real laboratory in term of students' achievement and conceptual understanding. Meanwhile, a study carried out by [8] proved that computer simulation can replace real laboratory apparatus. In addition, a study carried out by [9] proved that the videotaped experiments can be an alternative for demonstration experiments.

In [10] introduced Visualization Approach Teaching Aid (VATA) which consists of video recorded experiment based on multi-frames display system. It was used as an alternative for real laboratory experiment so that students can develop their science process skill such as observing, measuring and using numbers and interpreting data although they could not carry out the experiment themselves due to time constraint and students' safety. In addition, students can observe any changes which could be occured during experiment to eliminate their misconceptions. In [11] developed a Multi-

frame Assisted Teaching Approach (MATA) module for capacitor topic by integrating VATA and Computer Assisted Instruction. MATA module comprises of two components; PowerPoint slides and multi-frames video recorded experiments (MFVREs). The MATA module was used as teaching aid during T&L session to improve students' understanding in physics subject. They studied the effectiveness of MATA module on pre-university students' achievement. It was found that the achievement of experimental group (students taught using MATA module) was significantly better compared to control group (students taught using conventional method). However, they did not determine which components of MATA module, either PowerPoint slides or MFVREs, give better impact to students' achievement.

In this study, we determine the effectiveness of MFVREs on students' achievement for capacitor topic. The capacitor topic is selected because some previous researchers have discovered that students faced difficulties in determining the factors affect capacitance of a parallel-plate capacitor [12] and students have been confused about the equivalent capacitance for series and parallel connections of capacitors [13]. There are four MFVREs used in this study: basic concept of capacitor, series connection of capacitors, parallel connection of capacitors and combination of series and parallel connection of capacitors. The effectiveness of MFVREs refers to the comparison of students' achievement taught using MATA module (the combination of PowerPoint slides and MFVREs) and students' achievement taught using PowerPoint slides only which is embedded in MATA module.

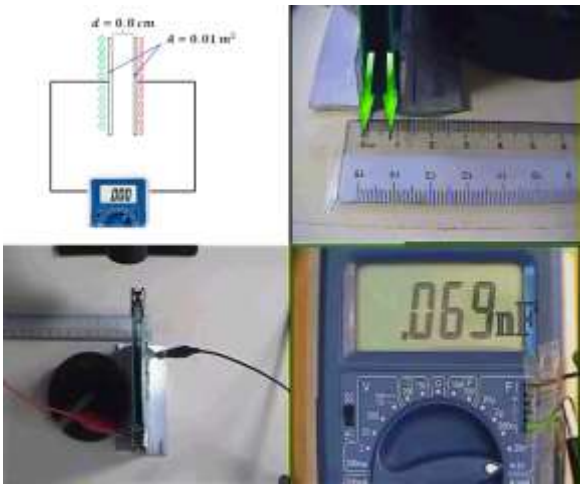
RESEARCH METHODOLOGY

A. Sampling Procedure

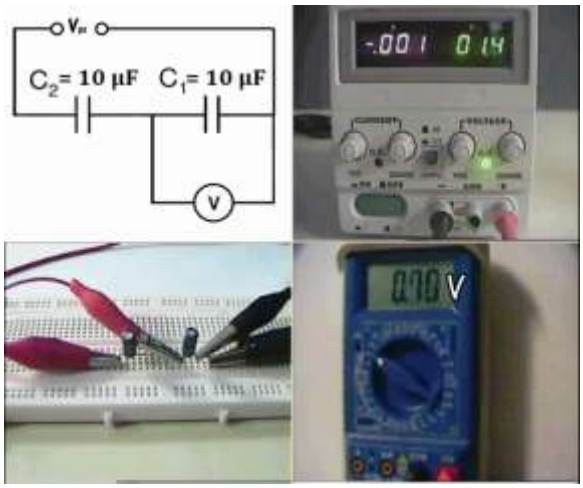
This study employs purposive sampling technique since the samples of this study were selected among students which will be taught the capacitor topic during their physics class at pre-university level. They were purposively selected among the first year students of Diploma Science from Universiti Pendidikan Sultan Idris (UPSI), Malaysia. Since all students could not randomly assign into experimental group (EG) and control group (CG), the samples were assigned into groups according to their natural settings (classes). Thus, four classes of students are selected where the first two classes were assigned as EG and the other two classes were assigned as CG. The EG consisted of 30 students with 11 males and 19 females while the CG also had 30 students with 12 males and 18 females.

B. Multi-frames Video Recorded Experiments (MFVREs)

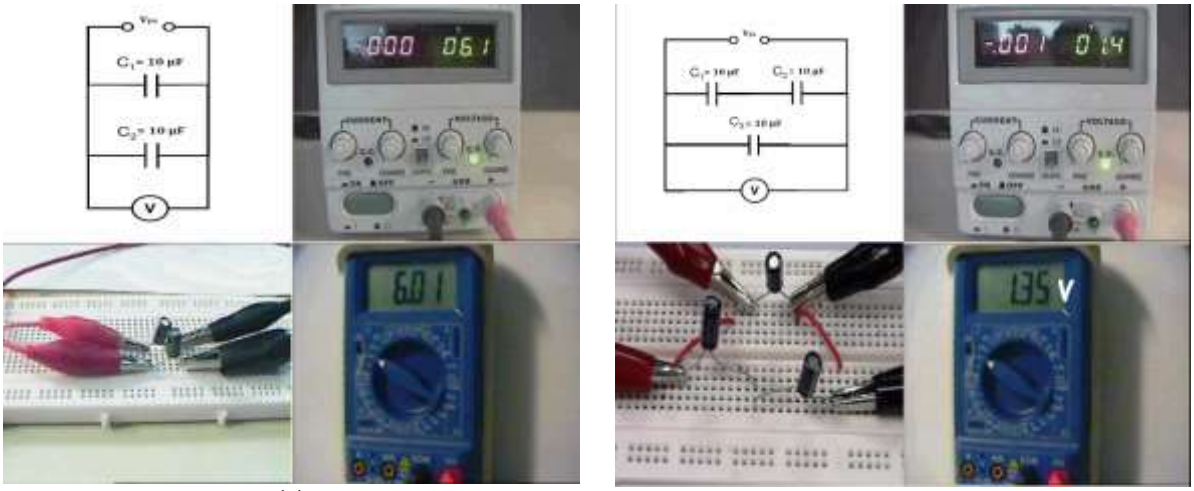
The video recorded experiments were developed based on multi-frames display system by utilizing digital video recorder (DVR) and four surveillance cameras. Four MFVREs used in this study are basic concept of capacitor, series connection of capacitors, parallel connection of capacitors and combination of series and parallel connection of capacitors as shown in Figure 1.



(a)



(b)



(c) (d)

Figure 1 MFVREs used in this study are (a) basic concept of capacitor, (b) series connection of capacitors, (c) parallel connection of capacitors and (d) combination of series and parallel connection of capacitors.

C. Research Instruments

Instruments used in this study were pre-test and post-test question sets. Pre-test and post-test were used to determine the effectiveness of MFVREs on students' achievement. Each question sets was divided into two parts; Part 1 related to the respondent profile such as their class, race and gender and Part 2 consist of 16 multiple choice questions (MCQs) related to capacitor topic. MCQs were lecturer-made achievement test which were developed based on learning outcomes of physics course and refined by four experienced physics lecturers before being used in pre-test and post-test. Questions are covered four subtopics: basic concept of capacitor (S1), series connection of capacitors (S2), parallel connection of capacitors (S3) and combination of series and parallel connection of capacitors (S4). Each question came with four alternative answers and the minimum score for this test was zero while the maximum score was 16. Table 1 shows maximum score for each subtopic in pre-test and post-test question sets.

Table 1 Maximum Score for Each Subtopic in Pre-test and Post-test Question Sets

	Subtopic	Question No.	Maximum Score
S1	Basic concept of capacitor	1, 2, 3, 4	4
S2	Series connection of capacitors	5, 6, 7, 8	4
S3	Parallel connection of capacitors	9, 10, 11, 12	4
S4	Combination of series and parallel connection of capacitors	13, 14, 15, 16	4

D. Data Collection and Analysis Procedures

EG and CG students were subjected to pre-test at the beginning of the study. Then, EG students were taught using PowerPoint slides and MFVREs by their course lecturer. The same lecturer also taught CG students using PowerPoint slides only. The treatment for both groups lasted for four weeks. There were two sessions for each week and each session lasted for one hour. For the first week, students were taught about the basic concept of capacitor. Then, students were taught about the series connection of capacitors for the second week and the parallel connection of capacitors for the third week. For the last week, students were taught about the combination of series and parallel connection of capacitors. After four weeks of treatment session, post-test were conducted for both groups. Students' scores for pre-test and post-test were analysed using independent sample t-test.

RESULT AND DISCUSSION

Table 2 shows descriptive and inferential statistical analysis for mean score of pre-test. According to analysis, the value of t is −0.086 and sig. (2-tailed), p = 0.932. Since the values of p are greater than 0.05, there is no significant difference for mean score of pre-test between EG and CG. The findings indicate that both groups have equivalent prior knowledge for capacitor topic.

Table 2 Descriptive and Inferential Statistical Analysis for Mean Score of Pre-test

Group	N	Mean Score	Standard Deviation (s. d.)	t	Sig. (2-tailed)
CG	30	3.633	1.402	−0.086	0.932
EG	30	3.667	1.605		

*significant level at p = 0.05

Difference mean score is the difference between pre-test and post-test scores which represents students' achievement for the topic. Descriptive and inferential statistical analysis for difference mean score is shown in Table 3. According to analysis, the value of t is −6.078 and sig. (2-tailed), p = 0.000. Since the values of p are less than 0.05, there is a significant difference for difference mean score between EG and CG. Therefore, the MFVREs are proved to give a significant effect to students' achievement for capacitor topic among the second semester Diploma Science UPSI students.

Table 3 Descriptive and Inferential Statistical Analysis of Difference Mean Score

Group	N	Mean score		Diff. mean score	s. d.	t	Sig. (2-tailed)
		Post-test	Pre-test				
CG	30	5.133	3.633	1.500	1.635	−6.078	0.000
EG	30	8.533	3.667	4.867	2.556		

*significant level at p = 0.05

Difference mean score for each subtopic is analysed to determine the effect of each MFVRE to students' achievement. Table 4 shows descriptive and inferential statistical analysis of difference mean score for each subtopic of capacitor. According to analysis for independent samples t-test, there is no significant difference score of difference mean score for S1 [t = 0.719, p = 0.475] subtopic. The use of MFVRE for basic concept of capacitor in T&L session gives similar effect as PowerPoint slides to students' achievement probably due to the limited function of MFVRE as it only demonstrates the effect of area of parallel-plate capacitor, separation distance and dielectric materials to the capacitance of capacitor. The MFVRE could attract students' attention to learn capacitor topic. However, it possibly unable to encourage students to actively participate in T&L session since students' participation is one of crucial factors to improve students' achievement [14, 15].

Table 4 Descriptive and Inferential Statistical Analysis of Difference Mean Score for Each Subtopic

Subtopic	Group	N	Mean score		Diff. Mean score	s. d.	t	Sig. (2-tailed)
			Post-test	Pre-test				
S1	CG	30	1.667	1.100	0.567	1.278	0.719	0.475
	EG	30	1.700	1.400	0.300	1.579		
S2	CG	30	0.633	0.467	0.167	0.874	−4.698	0.000
	EG	30	2.133	0.600	1.533	1.332		
S3	CG	30	1.667	1.000	0.667	1.446	−2.529	0.014
	EG	30	2.433	0.900	1.533	1.196		
S4	CG	30	1.167	1.067	0.100	1.423	−3.736	0.000
	EG	30	2.267	0.767	1.500	1.480		

*significant level at p = 0.05

However, there are significant differences of difference mean score for the other three subtopics: S2 [$t = -4.698$, $p = 0.000$], S3 [$t = -2.529$, $p = 0.014$] and S4 [$t = -3.736$, $p = 0.000$]. The finding indicates that the MFVREs for series connection of capacitors, parallel connection of capacitors and combination of series and parallel connection of capacitors have significant effects to students' achievement compared to PowerPoint slides. The main objective of MFVREs is to demonstrate experiments for series connection of capacitors, parallel connection of capacitors and combination of series and parallel connection of capacitors. In addition, all three MFVREs show the working principles to solve the simple problem related to series connection of capacitors, parallel connection of capacitors and combination of series and parallel connection of capacitors. The MFVREs also consist of several complex problems to be solved such as to determine the capacitance value of an unknown capacitor in the combination of series and parallel circuits. Thus, students have to analyze and solve the problems by applying the concepts of equivalent capacitance, total charge and potential difference for series and parallel circuits. Therefore, the problem solving approaches which require students to be actively participated in T&L session can improve students' achievement [16, 17].

CONCLUSION

The effectiveness of multi-frames video recorded experiments (MFVREs) on students' achievement for capacitor topic is successfully analyzed in this study. The findings indicate that MFVREs can improve students' achievement compared to PowerPoint slides. The MFVREs for series connection of capacitors, parallel connection of capacitors and combination of series and parallel connection of capacitors have significant effects to students' achievement compared to PowerPoint slides. In contrast, only MFVRE for basic concept of capacitor have insignificant effect to students' achievement probably due to the limited function of MFVRE. However, these results can only be generalized among the first year pre-university UPSI students. Hence, a further study should be carried out for larger sample to determine the effectiveness of MFVREs on pre-university students' achievement before large-scale implementation.

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