Development and Evaluation of Multi-frames Video Recorded Experiments as Self-learning Materials for Electricity Topic

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ABSTRACT

The purpose of this study is to develop and evaluate Multi-frames Video Recorded Experiments (MFVREs) as self-learning materials for Electricity topic of the Malaysian Form Five Physics curriculum. The development of MFVREs consisted of eight steps; selecting topic, selecting related experiments, preparing apparatus and materials for experiments, testing experiments, setting up recording apparatus, recording experiments, editing MFVREs and testing MFVREs. The MFVREs comprised of four subtopics; electric field and charge flow, relationship between current and potential difference, series and parallel circuits and electromotive force and internal resistance. The compatibilities of MFVREs as self-learning materials were evaluated from their effectiveness's towards students' achievement and students' perceptions towards MFVREs. The samples of this study consisted of 40 Form Five students of a secondary school in Slim River and they were equally and randomly divided into the experiment and control groups. The experiment group used MFVREs as self-learning materials together with a printed module while the control group used only the printed module. The findings showed that there was a significant difference in achievements between control and experiment groups and students of experiment group showed positive perceptions towards the design and content of MFVREs. Therefore, MFVREs are effective as self-learning materials to improve students' achievements in learning Physics.

Keywords: *Multi-frames Video Recorded Experiments (MFVREs), self-learning materials, Electricity topic, Form Five*

INTRODUCTION

Experiment is an important activity in science teaching and learning (T&L) as it encouraged students to investigate phenomena that occur in our daily life using scientific method (Ramly, *et al.*, 2014; Ramly, *et al.*, 2016). Experiment is essential to improve students' process skills (Lati, Supasorn, & Promarak, 2012; Musasia, Abacha & Biyoyo, 2012) and attitude towards Science subject (Ateş & Eryilmaz, 2011; Musasia, Abacha & Biyoyo, 2012; Ural, 2016). Experiment is also important to improve students' achievement compared to the conventional lecture approach in Basic Science (Cardak, Onder & Dikmenli, 2007; Dhanapal & Zi Shan, 2014; Etiubon & Udoh, 2017), Biology (Ogundiwin, *et al.*, 2015), Chemistry (Demircioğlu & Yadigaroğlu, 2011; Lati, Supasorn, & Promarak, 2012; Akani, 2015; Ural, 2016) and Physics (Ateş & Eryilmaz, 2011; Musasia, Abacha & Biyoyo, 2012; Musasia, Ocholla & Sakwa, 2016).

However, some experiments could not be performed due to several factors such as time constraints,

lack of special equipments and safety issues (Ramly, *et al.*, 2014; Ramly, *et al.*, 2016). Therefore, the integration of information and communication technology (ICT) with experiment can solve the problems. Previous researches confirmed that both virtual and traditional laboratory produced the same result for students' achievement (Bayrak, Kanli & Ingec, 2007; Yang & Heh, 2007; Tüysüz, 2010; Tatli & Ayas, 2013) and conceptual change (Başer & Durmuş, 2010). Meanwhile, another study which was carried out by Sever, Yurumezoglu and Oguz-Unver (2010) proved that both recorded experiments and real demonstration by teachers gave the same effect towards students' achievement. Therefore, virtual and recorded experiments can be used as alternative to the traditional laboratory.

Recorded experiment can be used as teaching and learning materials to enhance students' achievement in Science subject. Moll and Milner-Bolotin (2009) studied the effect of Interactive Lecture Experiments (ILEs), the integration of videotaped demonstrations and lecture on students' achievement in Physics subject. The findings showed that ILEs encouraged active learning environments since students participated actively in the T&L session and improved students' achievement in Physics. Meanwhile, Ramly, *et al.* (2014) integrated the use of PowerPoint slide presentation with video recorded experiments to improve students' achievement in Physics subject. The finding of the study proved that the integration of PowerPoint slides presentation with multi-frame video recorded experiments (MFVREs) can be used as teaching materials to improve pre-university students' achievement for Capacitor topic. The finding of another study carried out by Ramly, *et al.* (2016) found that MFVREs themselves can also be effectively used as teaching materials. In the meantime, Hon, Jaafar and Abdullah (2018) developed Visual-Audio Multimedia Module (VAMM) for Light topic by integrating instructional videos, recorded demonstrations and exercise videos as self-learning materials. Their findings indicated when VAMM was successfully improved students' achievement compared to the conventional self-learning module. However, the effectiveness of video recorded experiments themselves as self-learning materials has never been empirically studied.

Therefore, we developed self-learning videos based on multi-framed recorded experiments for Electricity topic of Malaysian Form Five Physics curriculum in this study. The developed videos covered four Electricity subtopics; electric field and charge flow, relationship between current and potential difference, series and parallel circuits, and electromotive force and internal resistance. In this study, the compatibilities of videos as self-learning materials were evaluated in term of their effectiveness towards students' achievement and students' perceptions towards MFVREs' design and content.

Research Questions

The research questions are as follows:

1) What are steps required to develop the MFVREs as self-learning materials?

2) Are MFVREs able to improve students' achievement compared to the printed self-learning module?

3) What are the students' perceptions towards MFVREs in term of their design and content?

Research Hypothesis

The two research hypotheses for this study are:

H_{o1}: There is no significant difference in the mean pretest scores between students of control and experimental groups.

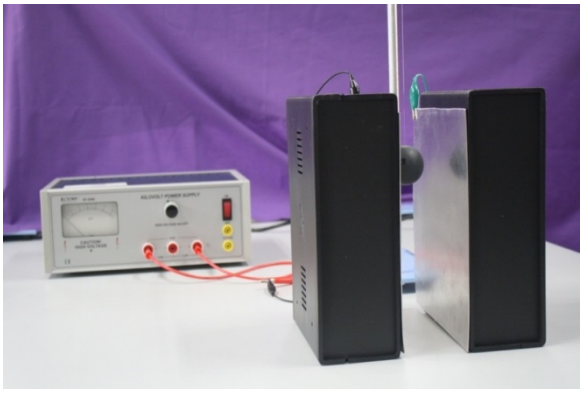
H_{o2}: There is no significant difference in the mean achievement scores between students of control and experimental groups.

RESEARCH METHODOLOGY

This study comprises of two parts. The first part involves the development of MFVREs for Electricity topic and the second part involves the evaluation of MFVREs as self-learning materials.

Development of MFVREs for Electricity Topic

The development of MFVREs for Electricity topic comprises of eight steps; selecting the topic, selecting related experiments, preparing the apparatus and materials for experiments, testing experiments [Figure 1(a)], setting up recording equipments [Figure 1(b)], recording experiments [Figure 1(c)], editing MFVREs [Figure 1(d)] and testing the MFVREs.



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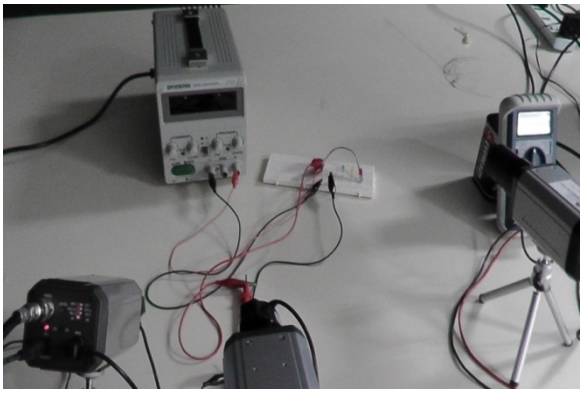

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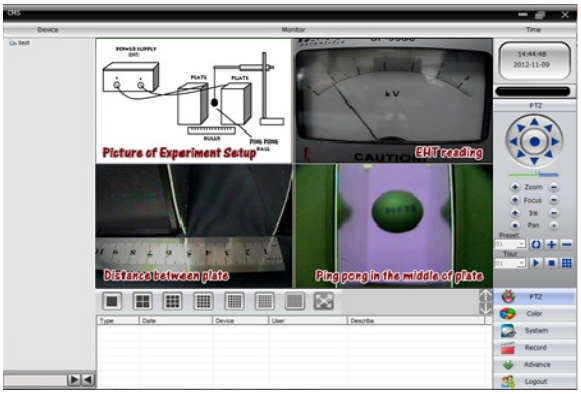


(c)

(d)

Figure 1. The development of MFVREs includes (a) testing experiment, (b) setting up recording apparatus, (c) recording experiments, and (d) editting MFVREs.

The first step involved selecting the topic. The Electricity topic consists of four subtopics; electric field and charge flow, relationship between current and potential difference, series and parallel circuits and electromotive force and internal resistance. The Electricity topic was selected since the findings of previous studies showed that students faced difficulties in understanding series and parallel circuits (Brown, 2003; Vetter & Beichner, 2004; Başer & Durmuş, 2010) and electromotive force (Garzón, *et al.*, 2014). After that, relevant and suitable experiments for the topic were selected in the second step. Eight experiments were selected including the electric field and charge flow, the relationship between electric current and potential difference, the effect of conductor length on its resistance, the effect of conductor cross sectional area on its resistance, the effect of material type on its resistance, the series circuit, the parallel circuit, and the electromotive force and internal resistance.

The third step involved the preparation of apparatuses and materials for selected experiments. Then, apparatuses and materials were tested to ensure that all apparatus and materials were in good conditions

for the recording session in the fourth step. The fifth step was about setting up of the recording apparatus. Every precautionary steps were taken to avoid interruptions during the recording session. In the sixth step, experiments were recorded using Closed-circuit Television (CCTV) camera and CamStudio-Recorder software. After that, MFVREs were edited using Corel Video Studio Pro X4 software so that the recorded videos were consistent with learning objectives of Electricity topic in the seventh step. Finally, MFVREs were tested in terms of their display and playback rate to ensure that the compatibility of MFVREs as self-learning materials. The flow chart for the developmental process of MFVREs is shown in Figure 2.

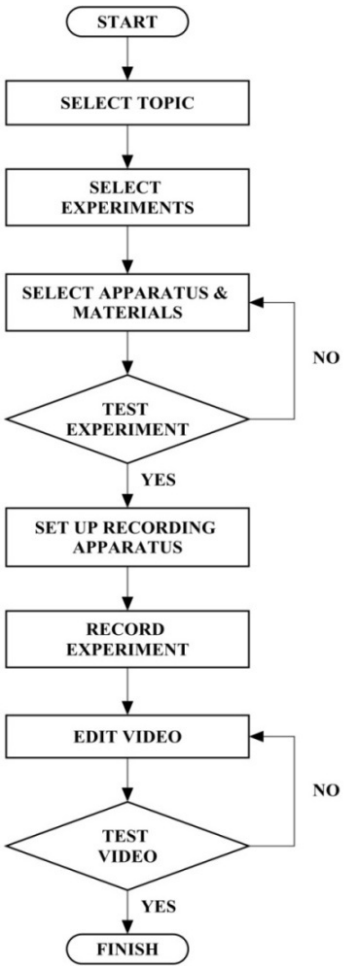


Figure 2. Flow chart for development of MFVREs.

Evaluation of MFVREs as Self-Learning Materials

This quantitative study used the quasi-experimental design involving two equally and randomly divided groups; control and experiment groups. This sudy involved 40 Form Five students of a secondary school in Slim River, Perak who were selected using the purposive sampling technique. In this study, the students were instructed to learn the Electricity topic themselves using two different self-learning methods. Students of control group learnt the topic using 42 pages of printed self-learning module which comprised of four subtopics; electric field and charge flow, relationship between current and potential difference, series and parallel circuits and, electromotive force and internal resistance. Each subtopic in the module contained the learning outcomes, an explanation about the concept and solution for problems of the subtopic. Meanwhile, students of experiment group learnt the same topic using the same printed module together with MFVREs as self-learning materials.

The MFVREs were evaluated from two aspects; the effectiveness of MFVREs towards students' achievement and students' perceptions towards MFVREs. The effectiveness of MFVREs towards students' achievement were determined using pretest and posttest. Both tests consisted of 16 multiple choice

questions from four subtopics being investigated. Meanwhile, a questionnaire was used to determine students' perceptions towards MFVREs in terms of their design and content. The questionnaire contained 10 items using the Likert scale valued from 1 to 5 where 1 represented Strongly Disagree (SD), 2 represented Disagree (D), 3 represented Uncertain (U), 4 represented Agree (A) and 5 represented Strongly Agree (SA).

The pretest and posttest as well as the questionaire were validated by four notable reviewers; an experienced Physics lecturer, an experienced Physics Education lecturer and two Physics teachers with about 10 years of teaching experiences. The pretest and posttest were evaluated in terms of their face and content validities so that the questions were consistent with the learning objectives in Electricity topic as prescribed by the Malaysian Form Five Physics curriculum and the content of MFVREs. Meanwhile, the questionnaire was evaluated in terms of its construct validity to ensure that the questionaire items were able to determine students' perceptions towards the design and content of MFVREs.

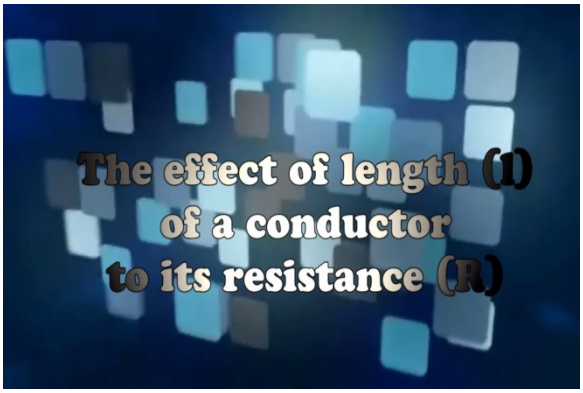
A pilot study was conducted to determine the instruments' reliability. 15 Form Five students who did not participated in the control and experiment groups took part in the pilot study. The findings of pilot study showed that the reliability coefficient of pretest and posttest were 0.842 which proved that both tests were suitable to determine students' level of understanding in Electricity topic. Meanwhile, the reliability coefficients of questionnaire for the design and content of MFVREs were 0.962 and 0.958, respectively. This showed that the questionnaire items were suitable to determine students' perceptions towards the design and content of MFVREs.

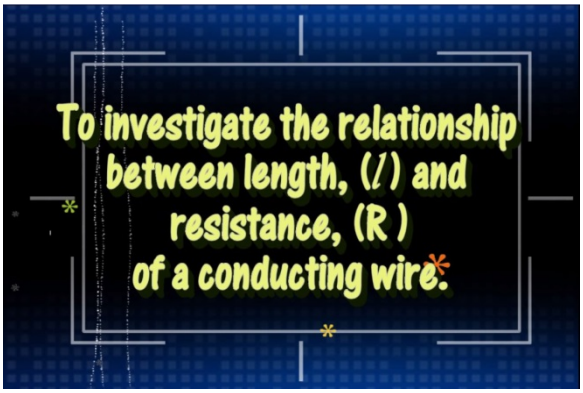
The MFVREs were used by the students as self-learning materials during self-learning session. At the beginning of the study, the pretest was administered to all students of both groups. The students were then instructed to learn the Electricity topic on their own for four weeks. As was mentioned earlier, students of control group were provided with printed modules while students of experiment group were provided with the same printed modules and MFVREs. At the end of the fourth week, the posttest was administered to both groups. The students of experiment group were also instructed to respond to a questionnaire to determine their perceptions regarding the usage of MFVREs in terms of their design and content.

RESULTS AND DISCUSSIONS

Multi-frame Video Recorded Experiments (MFVREs) for Electricity Topic

The main purpose of this study was to develop the MFVREs. Therefore, the characteristics of text were important because letters, words or sentences can help convey ideas or information to students effectively. Meanwhile, the graphical elements in MFVREs were also important since they could help improve students' motivation to use MFVREs in learning science subject. Similarly, the video elements were also important in explaining the correct procedure to conduct experiments in Electricity topic. Each MFVRE was made up of five main components; title of experiment, purpose of experiment, materials and apparatus, procedure to conduct experiment, and video recorded experiment as shown in Figure 3.





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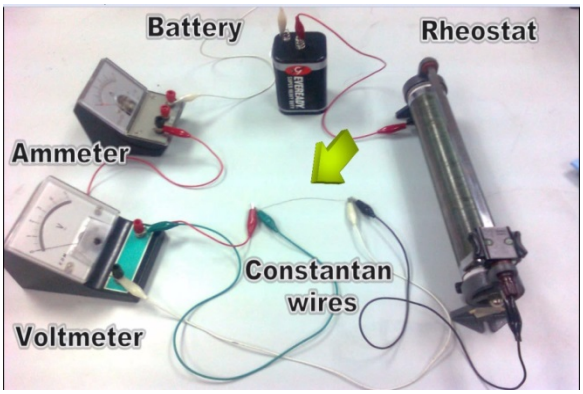

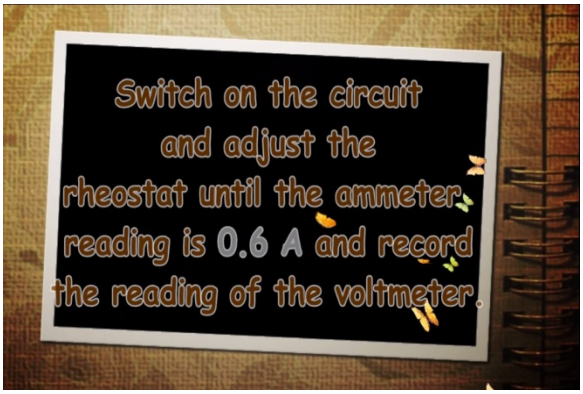

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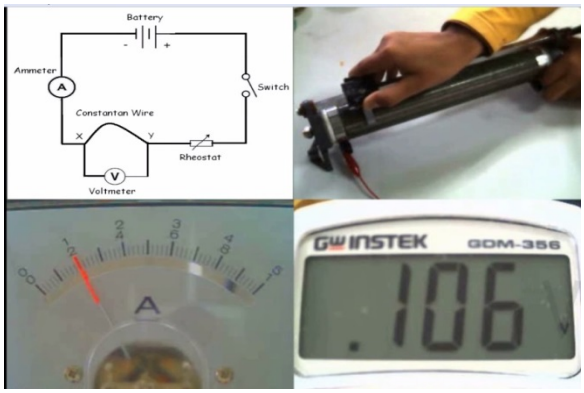

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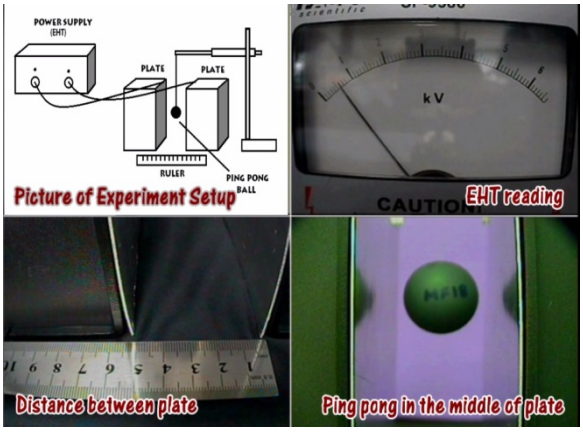
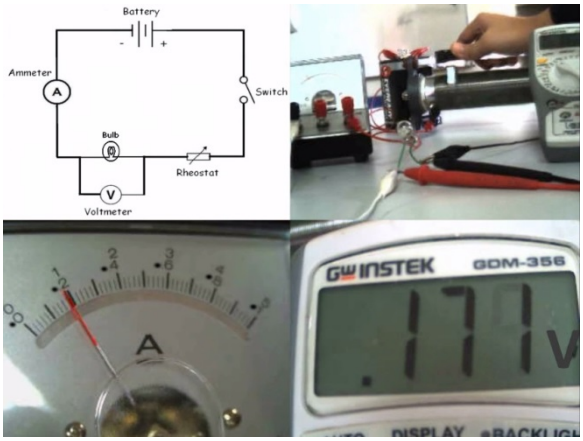
Figure 3. Each MFVRE comprises of (a) title of experiment, (b) objective of experiment, (c) material and apparatus, (d) procedure of experiment and (e) video recorded experiment.

Eight MFVREs were developed in this study that covered four subtopics and six concepts. The four subtopics were electric field and charge flow, relationship between current and potential difference, series and parallel circuits, and electromotive force and internal resistance while the six concepts in Electricity were electric field and charge flow, relationship between electric current and potential difference, factors affecting resistance, series circuit, parallel circuit and electromotive force and internal resistance as shown in Figure 4.





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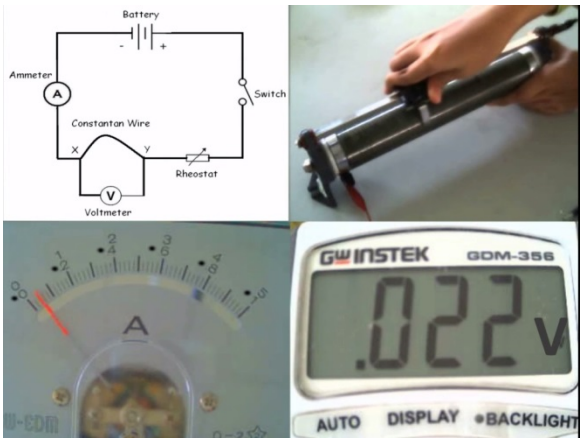

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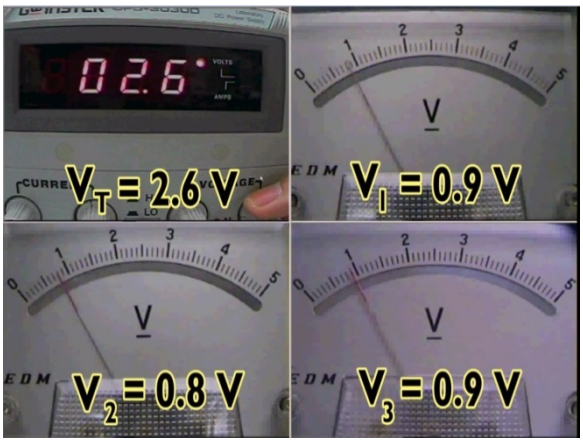

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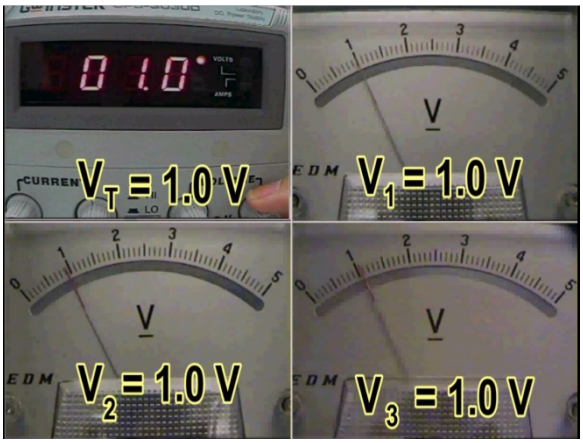

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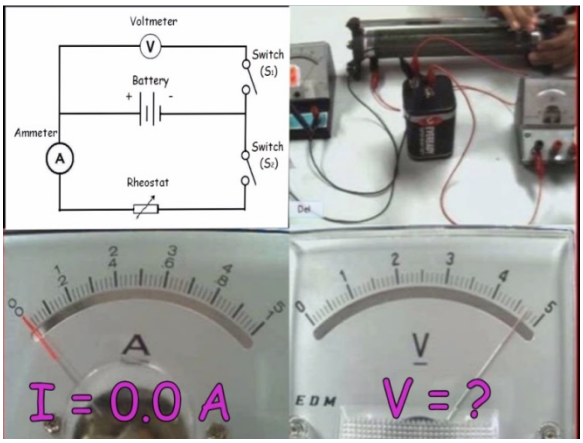

(f)

Figure 4. MFVREs consist of six concepts; (a) electric field and flow of charge, (b) relationship between electric current and potential difference, (c) factors affecting resistance, (d) series circuit, (e) parallel circuit, and (f) electromotive force and internal resistance.

Evaluation of MFVREs as Self-learning Materials

The MFVREs were evaluated as self-learning materials by determining the effectiveness of MFVREs towards students' achievement and students' perceptions towards MFVREs.

Effectiveness of MFVREs towards Students' Achievement

The effectiveness of MFVREs towards students' achievement was determined using pretest and posttest and testing two research hypotheses. The first research hypothesis was tested to determine the status of students' prior knowledge for both groups by analysing the pretest scores.

H_{o1}: There is no significant difference in the mean pretest scores between students of control and experimental groups.

The descriptive and inferential statistical analysis of mean pretest scores between control and experiment groups are shown in Table 1. The values of mean pretest score and its standard deviation for control group were 6.650 and 2.007, respectively. Meanwhile, the values of mean pretest score and its standard deviation for experiment group were 6.500 and 1.878, respectively. Although mean pretest score of control group was higher compared to mean pretest score of experiment group, the independent sample t-test analysis was carried out to determine its significance. According to the analysis, the t value was 0.244

and sig. (2-tailed), p = 0.809. Since the value of p was greater than 0.05, there was no significant difference for mean pretest score between control and the experiment groups. Therefore, the first hypothesis was failed to be rejected. The finding also indicated that students of both control and experiment groups have equivalent prior knowledge for Electricity topic.

Table 1. Descriptive and inferential statistical analysis for mean pretest scores.

Group	N	Mean score	Standard deviation (s.d.)	t	Sig. (2-tailed)
control group	20	6.650	2.007	0.244	0.809
experiment group	20	6.500	1.878		

*significant level at p = 0.05

Then, the second research hypothesis was tested to determine the effectiveness of MFVREs as self-learning materials by analysing the scores of pretest and posttest for both groups.

H_{o2}: There is no significant difference in the mean achievement scores between students of control and experimental groups.

Mean achievement score is the difference between pretest and posttest mean scores. The descriptive and inferential statistical analysis for mean achievement scores between control and experiment groups are shown in Table 2. The values of mean achievement score and its standard deviation for control group were 1.800 and 2.042, respectively. Meanwhile, the values of mean achievement score and its standard deviation for experiment group were 6.550 and 2.946, respectively. Although the mean achievement score of control group was higher compared to the mean achievement score of experiment group, the independent sample t-test analysis was carried out to determine its significance. According to the analysis, the value of t was –5.926 and sig. (2-tailed), p = 0.000. Since the value of p was less than 0.05, there was no significant difference for mean achievement score between control and experiment groups. Therefore, the second hypothesis was rejected.

Table 2. Descriptive and inferential statistical analysis for mean achievement scores.

Group	N	Mean score		Mean achievement score	s.d.	t	Sig. (2-tailed)
		Posttest	Pretest				
control group	20	8.450	6.650	1.800	2.042	–5.926	0.000
experiment group	20	13.050	6.500	6.550	2.946		

*significant level at p = 0.05

MFVREs consist of three multimedia elements; text, graphic and recording of real experiments while the printed self-learning module consists of text and graphic. Since the main difference between MFVREs and printed self-learning module was recording of real experiments, the findings confirmed that the video recorded experiments as self-learning materials can improve students' achievement. This was well documented since the recorded experiments were able to enhance students' conceptual understanding (Bartholomew, Oyedepo & Yusuf, 2011; Harman, *et al.*, 2016). In addition, the recorded experiments could produce the same results as the traditional laboratory in improving students' achievement (Bayrak, Kanli & Ingec, 2007; Yang & Heh, 2007; Tüysüz, 2010; Tatli & Ayas, 2013). Furthermore, the development of video recorded experiments according to the multi frame system allowed students in observing the relationship between independent and dependent variables simultaneously. Thus, MFVREs have improved students' achievement in Physics subject as self-learning materials.

Students' Perceptions towards MFVREs

Students' perceptions towards MFVREs were evaluated in terms of their design and content. In this study, the level of students' perceptions was determined based on the study by Saripah Salbiah, *et al.* (2013). They studied the students' perception towards Interactive Multimedia Chemistry Module (IMCM) for the

topic of Stereochemistry and Mechanism of Nucleophilic Substitution Reactions SN1 and SN2. Students' perception was categorized as negative when more than 50% students chose SD and D and positive when more than 50% students chose A and SA as shown in Table 3.

Table 3. Level of Students' Perceptions (Saripah Salbiah, *et al.*, 2013).

Students' Choice	Level of Perception
More than 50% students choose SD and D	Negative (N)
More than 50% students choose A and SA	Positive (P)

*Note: SD (Strongly Disagree), D (Disagree), A (Agree), SA (Strongly Agree)

The students' perceptions towards the design of MFVREs was determined from items 1 to 5 of the questionaire as shown in Table 4. According to the results in Table 4, most students have positive perception towards the design of MFVREs (61%) as videos have appropriate font (60%), videos have appropriate text colour (75%), videos have appropriate graphics (65%), the video presentation can attract users' attention to learn (50%) and the displayed data or meter is easy to be read (55%).

Table 4. Students' perceptions towards the design of MFVREs.

No.	Item	Percentage (%)					Perception (%)	
		SD	D	U	A	SA	N	P
1.	These videos have appropriate font	5	5	30	50	10	10	60
2.	These videos have appropriate text colour	0	10	15	75	0	10	75
3.	These videos have appropriate graphics	0	10	25	60	5	10	65
4.	The video presentation can attract my attention to learn	0	15	35	50	0	15	50
5.	The displayed data or meter is easy to be read	15	10	20	45	10	25	55
					Overall Perception		14	61

*Note: SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree), N (Negative), P (Positive)

The students' perceptions towards the content of MFVREs was determined from questionnaire item 6 to 10 of the questionaire as shown in Table 5. In Table 5, most students have positive perception towards the content of MFVREs (68%) as learning objectives are clearly stated in the videos (70%), learning objectives are consistent with the content of videos (85%), the content of videos meet users' expectations (55%), the videos help user in learning Electricity concept (75%) and the contents of videos are easy to understand (55%).

Table 5. Students' perceptions towards the content of MFVREs.

No.	Item	Percentage (%)					Perception (%)	
		SD	D	U	A	SA	N	P
6.	Learning objectives are clearly stated in the videos	0	0	30	55	15	0	70
7.	Learning objectives are consistent with the content of videos	0	0	15	75	10	0	85
8.	The content of videos meet my expectations	0	10	35	40	15	10	55
9.	The videos help me in learning Electricity concept	0	10	15	50	25	10	75
10.	The contents of videos are easy to understand	0	20	25	45	10	20	55
					Overall Perception		8	68

*Note: SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree), N (Negative), P (Positive)

Therefore from Table 4 and 5, students have positive perceptions towards the design and content of MFVREs. This was probably due to the usage of the right font, appropriate text colour and graphic embedded in the videos, attractive video presentations and clear data or meter display, which can attract students' attention while they were using MFVREs. Furthermore, the learning objectives were clearly stated and consistent with the videos' content. In addition, the videos' content were easy to understand and met students' expectation. Students also agreed that the videos can help them in learning Electricity concept. Thus, MFVREs were effective self-learning materials.

Research Limitations

1) The development of MFVREs as self-learning materials were limited to the four Electricity subtopics; electric field and charge flow, relationship between current and potential difference, series and parallel circuits and electromotive force and internal resistance.

2) The evaluation of MFVREs as self-learning materials were determined only from pretest and posttest about the topic being investigated and the questionnaire about MFVREs.

3) The sample were limited to Form Five students of a simgle secondary school in the state of Perak and;

4) This study did not take into account several confounding factors such as socioeconomic status, race and gender.

CONCLUSION

Multi-frames Video Recorded Experiments (MFVREs) for Electricity topic of the Form Five Physics syllabus have been successfully developed in this study. The findings indicated that the utilization of MFVREs as self-learning materials can improve students' achievements compared to self-learning conventional approach for Electricity topic. Besides, students also have positive perceptions towards the design and content of MFVREs. Thus, a further study should be carried out to improve the design and content of MFVREs so that they will be more effective and useful to help students for preparation of public examination during self-learning session.

ACKNOWLEDGMENT

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