Lee & Sulaiman, 2018

Volume 3 Issue 3, pp.1404-1419

Date of Publication: 5th February, 2018

DOI-https://dx.doi.org/10.20319/pijss.2018.33.14041419

This paper can be cited as: Lee, M., & Sulaiman, F., (2018). The Effectiveness of Practical Work in Physics to Improve Students' Academic Performances. PEOPLE: International Journal of Social Sciences, 3(3), 1404-1419.

THE EFFECTIVENESS OF PRACTICAL WORK IN PHYSICS TO IMPROVE STUDENTS' ACADEMIC PERFORMANCES

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Abstract

The purpose of this study is to investigate the effectiveness of physics practical work on students' academic performances and to compare male and female students' academic performances after the implementation of practical work in experimental group. This study was conducted in a secondary school at Semporna District in Sabah. A total of sixty-six (66) Form Four students (e.g., 16 years old) participated in this research; thirty-two (32) students were assigned to experimental group and thirty-four (34) students to control group. The experimental group and control group were taught by using practical work and traditional teaching method respectively. A quasi-experimental design was used in this study. Data on students' academic performances were analysed by using Statistical Package for Social Science (SPSS) Version 22.0 and Mann-Whitney U Test was used. Before the treatment, students in both groups showed no significant difference in their academic performances ($U = 489.00$, $p > 0.05$ is not significant) indicated *that the group of students is homogenous. Students' academic performances, however, have a statistical difference after the implementation of practical work (U = 380.00, $p < 0.05$ is significant). Gender analysis was done where male students in experimental group performed better than female students (U = 60.00, $p < 0.05$ is significant). It is suggested that educators should conduct practical work as frequent as possible (once a week) and increase the time of practical work to enhance students' understanding towards the physics concept.*

Keywords

Physics Practical Work, Traditional Teaching Method, Academic Performances, Physics Education

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1. Introduction

In Malaysia, physics subject is an elective subject where students pursue the subject during their upper secondary (Curriculum Development Centre, 2005b). According to Mahzan Bin Bakar, the Director of Curriculum Development Centre, physics curriculum targets to produce active learners where students have chances to partake in scientific investigation via hands-on activities and experimentations. One of the aims of the physics curriculum for secondary schools in Malaysia is to give students the knowledge and skills in science and technology. Therefore, students can solve problems and make decisions based on scientific attitudes and noble values in everyday life (Curriculum Development Centre, 2005a).

Physics is a difficult subject to learn (Veronika, Johannes, & G. Budijanto, 2017). Students always have this kind of perceptions and low confidence which lead to fewer students to take up physics at school (Fatin, Salleh, Bilal, & Salmiza, 2012). According to Dolin's study (as cited in Angell et al., 2004), physics needs students to learn many types of representation such as experiments, graphs and mathematical symbols. Students would have to understand and learn the transformation of all these representations. Other factors that hindrance students to study physics are because they are not interested in the subject, boring, difficult and irrelevant to daily life (Hirschfeld, 2012; Williams, Stanisstreet, Spall, Boyes, & Dickson, 2003). One of the reasons is because teachers have not self-confident enough to teach physics using practical work where they prefer to use traditional teaching method like chalk-and-talk. Some schools also have no proper laboratories to work on experiments (Kibirige & Tsamago, 2013). Besides, lack of laboratory facilities and less of exposure to practical instruction are also the factors lead to the poor achievement in physics at school (Daramola, as cited, in Musasia, Abacha, & Biyoyo, 2012). Teachers also lack exposure to science process skills to carry out activities in class (Rose, Sattar, Azlin, Zarina, & Lyndon, 2013). Therefore, teachers are trying to avoid the practical work in the laboratory which considers wasting time and they do not understand the importance of laboratory experiments (El-rabadi, 2013). Theoretical knowledge is always supported by the practical knowledge which helps students to expand their manipulative skills and scientific attitudes (Josiah, 2013). Therefore, practical work needs to be reinforced during physics class to change students' perception towards physics and improve the achievement. For this reason, researcher highlights, in this study, the effectiveness of physics practical work on students' academic performances. Furthermore, this study also compares the students' academic performances between male and female students after the implementation of practical work.

2. Literature Review

According to Science Community Representing Education (SCORE), practical work means '*a "hands-on" learning experience which prompts thinking about the world in which we live'* (Score, 2008). Besides, practical work can also be defined as *"...learning experience in which students interact with materials or with secondary sources of data to observe and understand the natural world"* (Lunetta, Hofstein, & Clough, 2007). Experimental work and scientific investigations are another ways to be called as practical work (Ramnarain, 2011). Students will learn the science concept by doing experiments in the Laboratory which is a different approach from "Chalk and Talk" method (Bruner, 1990). Therefore, laboratory experiment is one of the examples of practical work in secondary school level (Musasia et al., 2012).

The traditional teaching approach is defined as teaching is entirely depend on textbooks where the teacher teaches the content and students just sit, read, do assignments and taking notes (Ates & Eryilmaz, 2011). Traditional teaching classes look like a one-person show where usually controlled by direct and one-party instruction (Abida & Muhammad, 2012). At the same time, students are just unresponsively receiving the information from the teachers (Liu, 2014) and without questioning the teacher (Stofflett, 1999). According to a report done in Malaysia 1996 by Federal Schools Inspectorate (Jemaah Nazir Sekolah Persekutuan, as cited in Salmiza & Afik, 2012), teachers in Malaysia mostly were knowledgeable, familiar with the teaching contents and used various kind of techniques in teaching, yet, the teaching method was still teacher-centred.

This method of teaching is still going on after 15 years of the report has been published where the teaching practices is still a one way, teacher-centred which makes students behave passively in the classroom (Salmiza & Afik, 2012).

‘Hands-on’ methods are suggested in constructivist-based learning (Ng & Nguyen, 2006). Another alternative constructivist learning approach is the use of practical work in science teaching and learning. By having real-life phenomena, students are given the opportunities to evaluate and measure their views and to improve the understandings before the learning process (Ng & Nguyen, 2006). Practical work creates exceptional learning surrounding that help student to construct their knowledge, enhance logical, inquiry and psychomotor skills (Mashita, Norita, & Zurida, 2009). Besides, practical work offers an interactive experience to the students where they can broaden the scope of constructivist learning (Umar, Ubramaniam, & Ukherjee, 2005). The education system in Malaysia is still very exam-oriented which focuses on examination results and marks (Sharifah Fauziah, Farah, & Ismin Izwani, 2012). Malaysian teachers are also unfamiliar to apply constructivism approach in teaching. Therefore, teachers will be more to teacher-centred rather than student-centred and constructivism approach is unachievable (Arlina & Melor, 2014).

It is believed that by having practical work, students’ knowledge can be expanded to understand the real world (Millar, 2004). According to Ozdener’s study (as cited in Tüysüz, 2010), we know that students can gain knowledge of personal observation and involvement in practical work. Teaching objectives can be achieved easily by doing practical work especially in teaching physics (El-rabadi, 2013). Furthermore, first-hand knowledge of the physics concept will be generated where students can understand the abstract ideas which are difficult to explain during the class (Osborne, 2002). Students’ understanding of theories and models can also be developed (Millar & Abrahams, 2009). According to Inal’s study (as cited in Musasia et al., 2012), students are faster to understand the physics concepts when they test the experiment by themselves as they can touch the materials and apparatus which make them believe in the experiment.

3. Purposes and Research Questions

3.1 Purpose of the Study

The purposes of this study were:

(i) To investigate the effectiveness of physics practical work on students' academic performances.
(ii) To compare male and female students' academic performances after the implementation of practical work in experimental group.

3.2 Research Questions

(i) Is there any significant difference in students' post-achievement test between the control group and experimental group?
(ii) Is there any significant difference in students' post-achievement test between male and female students in the experimental group?

4. Research Methodology

4.1 Research Design

This study used quasi-experimental design which defined as lacks of random assignment which let the studies to be more practicable (White & Sabarwal, 2014). Apart from the fifty (50) minutes physics lesson in school, both groups were given extra sixty (60) minutes of equivalent time to carry out the research.

4.2 Research Samples

Two stages of sampling technique were used in this research. Firstly, purposive sampling was employed to select one of the schools in the district and all Form Four students from three (3) science classes of the school were used as the samples for the research. The respondents were purposively selected in this study was sixty-six (66) Form Four Science students (i.e., 23 males and 43 females) who took physics subject in the school. Furthermore, stratified sampling technique was used to select the respondents in the control group and experimental group according to their ability levels (Gambari, Obielodan, & Kawu, 2017). Therefore, thirty-two (32) students (i.e., 12 males and 20 females) were assigned to the experimental group, and thirty-four (34) students (i.e., 11 males and 23 females) were in control group. Table 1 showed the students distribution in experimental and control group.

Table 1: *Students' Distribution in Experimental and Control Group*

Group	Gender		Total
	Male	***Female***	
Experimental	12	20	32
Control	11	23	34
Total	23	43	66

4.3 Instruments

The pre-achievement test was used to measure the academic performances of both groups before treatment is implemented. There were twenty (20) multiple choice questions on the topic of "Forces and Motion". All the questions were mainly focused on physics concepts and calculations. The questions were adapted from different sources such as physics text-book, physics reference books and past year questions according to the Revised Bloom's Taxonomy. Due to students' English proficiency were low, the researcher translated all the tests and interview questions into Malay Language and verified by a qualified English Teacher. Two experts with teaching experience more than five (5) years in physics also validated the pre-achievement test and post-achievement test. All the questions in the post-achievement test were reshuffled and interchanged from pre-achievement test to avoid recognition (Gambari et al., 2017). For the reliability, the pre-achievement test was piloted on thirty-eight (38) Form 4 students from other schools to assess suitability and clarity of the questions. The Cronbach's Alpha (α) Coefficient obtained was 0.761.

4.4 Data Collection and Analysis

Students in control group were taught by traditional teaching method where students only listen to teacher's explanations and writing down the notes. Meanwhile, students in experimental group underwent the practical work teaching method. Six (6) experiments from the topic of "Forces and Motion" were conducted. Table 2 showed the list of experiments conducted in this research.

Table 2: *The List of Experiments*

No.	Experiment details
1.	To study the relationship between the mass and inertia.
2.	To analyse linear motion using ticker tape.
3.	To find the relationship between acceleration and force.
4.	To find the relationship between acceleration and mass.
5.	To determine the acceleration due to gravity.

6.	To investigate the relationship between a force and the extension of a spring.

After six (6) weeks of teaching, the students from both groups were sat for the post-achievement test again. After that, pre-achievement test and post-achievement test were analysed using SPSS Version 22.0. Mann-Whitney U Test was used to determine the effects of practical work on students' academic performances and compare male and female students' academic performances after the implementation of practical work in the experimental group. Figure 1 showed the flowchart of this study.

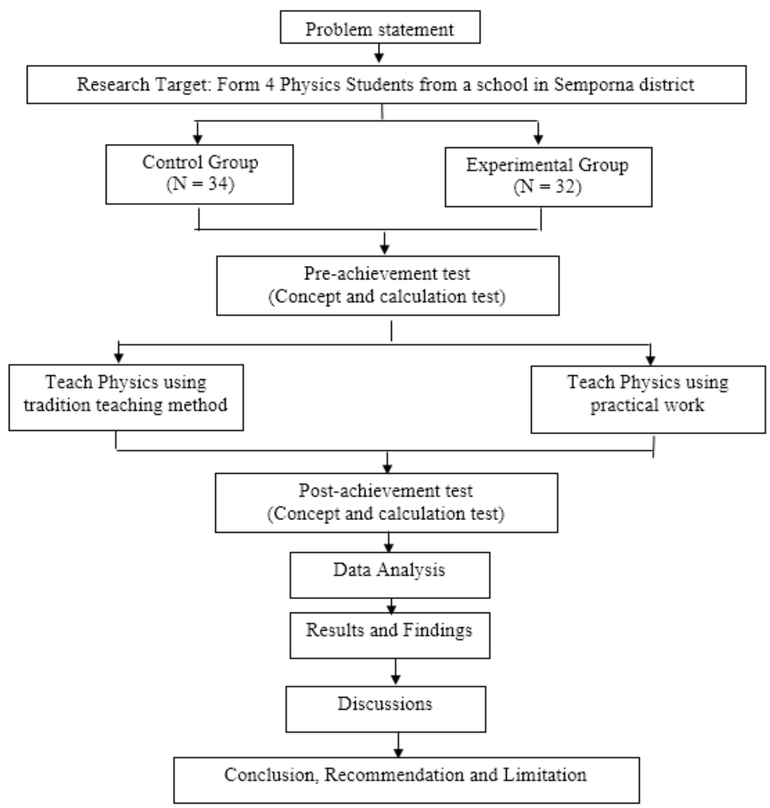

Figure 1: *Flowchart of the Study*

5. Results and Discussion

Since the data obtained were not in normal distribution and a small number of students in each group, nonparametric test which is Mann-Whitney U Test was carried out to analyse the data (Selçuk, 2010). Therefore, ranks, median or frequencies are focused in this study rather than the mean value (Pett, 2016). Students' academic performances of both groups before the treatment showed no significant difference whereby (U = 489.00, Z = -0.709, p = 0.478, p > 0.05

is not significant). The data analysis revealed that students in both groups were homogenous and had the same ability. Table 3 showed the mean rank for students in the experimental group were slightly higher than the control group. Mean rank for the experimental group was 35.22 and control group was 31.88. Therefore, according to the Mann-Whitney U test, there was no significant difference between experimental group and control group in their mean rank for the pre-achievement test.

Table 3: *Mean Rank of Students' Academic Performances for Both Groups before the Treatment*

Variable	Group	N	Mean Rank	Sum of Ranks	U	Z	p
Pre-achievement test	**Experimental Group**	32	35.22	1127.00	489.00	-0.709	.478
	Control Group	34	31.88	1084.00			

5.1 Students' Post-Achievement Test between Control and Experimental Group

The data analysis in this part is to find out the academic performances in physics of control and experimental group after the treatment. Table 4 showed the mean rank of students' academic performances of both groups after the treatment. Based on the Mann-Whitney U test results, students in experimental group and control group showed a significant difference between their mean rank for the post-achievement test (U = 380.00, Z = -2.120, p = 0.034, $p < 0.05$ is significant). The data analysis revealed that students in the experimental group were performed better than students in control group after the treatment. Table 4 and Figure 2 showed the results of Mann-Whitney U test where the mean rank for students in the experimental group was higher than the control group. Mean rank for the experimental group was 38.63 and control group was 28.68. Therefore, the null hypothesis (H_0^1), there is no significant difference in students' post-achievement test between the control group and experimental group is rejected.

Table 4: *Mean Rank of Students' Academic Performances for Both Groups after the Treatment*

Variable	Group	N	Mean Rank	Sum of Ranks	U	Z	p
Post-achievement test	**Experimental Group**	32	38.63	1236.00	380.00	-2.120	.034
	Control Group	34	28.68	975.00			

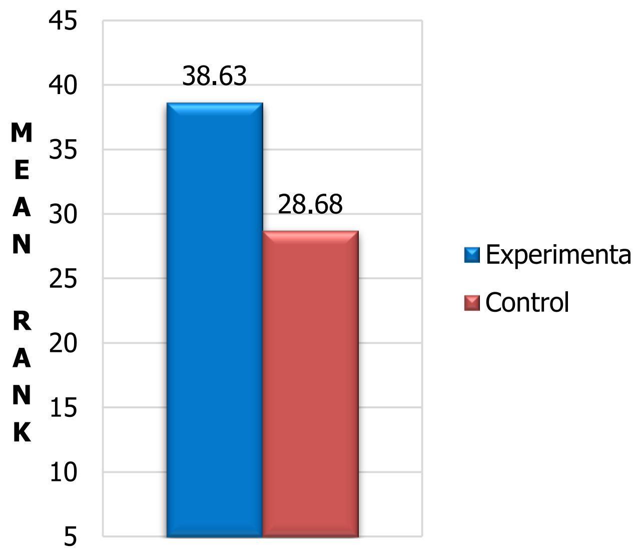

Figure 2: *Bar Chart on Comparison of Mean Rank for Post-Achievement Test in Both Groups*

Table 5 showed the mean gain scores of students between pre-achievement test and post-achievement test of both groups, and it was compared to show improvement in academic performances after the treatment. Both groups showed improvement in the post-achievement mean scores. However, the mean gain score of the experimental group was higher than the control group where the experimental group was 22.03 and control group was 19.11. Thus, again, the experimental group performed better compared to control group.

Table 5: *Mean Gain Scores of Students between Pre-achievement test and Post-achievement test for Both Groups*

Group	Pre-achievement test Mean	Post-achievement test Mean	Mean Gain Scores
Experimental Group	47.03	69.06	22.03
Control Group	42.65	61.76	19.11

Practical work influenced and improved students' academic performances where students can recall what they see and touch rather than what they listen (Adesoji & Olatunbosun, 2008). For weaker students, it is advised to use practical work while teaching as they can perform better compared to other students who taught by lecture method (Odubunmi & Balogun, 1991). Besides, there are studies found that to school where carry out practical work has a greater effect on their students' academic achievement in science courses (Sabri & Emuas, 1999). As we know that practical work can create good results in science (Buthelezi, 2012). Moreover, students who did well in the practical work can also excel in final physics examination (Musasia et al., 2012). The reason is that practical work helps students to remember the apparatus and equipment that have been used and gradually students' manipulative skills can be developed (Sani, 2014). It makes students have a deeper understanding of the subject content (Musasia et al., 2012).

5.2 Gender Difference on Post-Achievement Test in Experimental Group

The data analysis in this section is to identify gender difference in post-achievement test in the experimental group. Table 6 showed the mean rank of gender differences in academic performances for the experimental group. Based on the Mann-Whitney U test results, male and female students in the experimental group showed a significant difference between their mean rank of the post-achievement test (U = 60.00, Z = -2.351, p = 0.19, $p < 0.05$ is significant). The data analysis revealed that male students performed better than female students in physics. Table 6 and Figure 3 showed the results of Mann-Whitney U test where male students have a higher mean rank as compared to female students in their post-achievement test. Mean rank for male students were 21.50 and female students were 13.50. Therefore, the null hypothesis (H_0^2), there is no significant difference in students' post-achievement test between male and female students in the experimental group is rejected.

Table 6: *Mean Rank of Gender Difference in Academic Performances for Experimental Group*

Variable	Group	N	Mean Rank	Sum of Ranks	U	Z	p
Post-achievement test	Male	12	21.50	258.00	60.00	-2.351	.019
	Female	20	13.50	270.00			

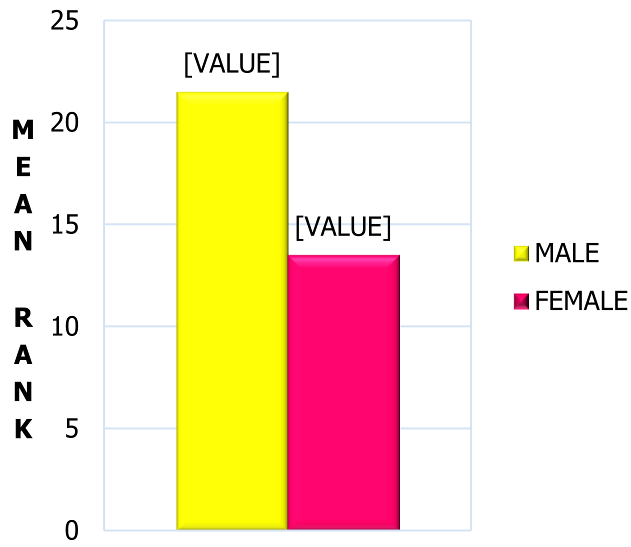

Figure 3: *Bar Chart on Comparison of Mean Rank for Post-Achievement Test in Experimental Group*

Practical work improved both male and female performances in physics sciences equally and did not differentiate against gender (Kibirige & Tsamago, 2013). Furthermore, by implementing practical work could improve both male and female academic achievement in physical sciences (Cardak, Onder, & Dikmenli, 2007). It was because practical work used cooperative learning among students to improve the performance of all learners regardless of gender (Kibirige & Tsamago, 2013). Furthermore, gender difference does not affect students' mastery of a science subject (Okam & Zakari, 2017). However, in this study showed that male students performed better than female students as they were more enthusiastic to learn how things worked and had a higher interest compared to female students in science class (Dare & Roehrig, 2016). Moreover, it is believed that male students understand the physics concept better than female students (Musasia, Ocholla, & Sakwa, 2016).

6. Conclusion and Suggestions

In short, students who conducted physics practical work indeed performed better than students who taught by using traditional teaching method. If a practical work is well planned and delivered expertly by the teacher, it may give an impact to students in their learning process. Besides, male students were performed better than female students in physics after the implementation of practical work as part of female students believed that science subject is way too complicated. The research limitations were the result of the study may not reflect all the secondary schools in the district as the study was carried out among students in a selected school. This research was only tested for Form Four students whereas Form Five students are not involved in this study. Besides, there was only one chapter with six (6) experiments were selected to carry out the research and it did not test other chapters in the syllabus. It is suggested that the research can be carried out in another district with a more substantial scale of respondents which involve Form Four and Form Five students. Furthermore, more experiments can be conducted to evaluate the effectiveness towards students. The teacher should also conduct practical work as frequent as possible (once a week) and increase the time to enhance students' understanding towards the physics concept.

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