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THE EFFECT OF LABORATORY PRACTICAL ACTIVITIES ON SENIOR HIGH SCHOOL STUDENT'S ACADEMIC PERFORMANCE IN RELATION TO FORCE CONCEPT

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Abstract

The problem of solving questions related to force faced by form two science students of St. James Seminary/Senior High School was an issue which led to this study. The problem of students' negative attitudes toward learning about force and their poor performance in force concepts was discovered through direct observation in the school setting. Students have shown difficulties understanding the concepts of force because they have difficulties with the kind of abstract thinking used by scientists. Additionally, because of the language that is used in our environment on a daily basis and since scientific terminology frequently differs from that of common speech, students usually have ideas that are different from those of scientists. It is commonly thought that teaching and understanding the concept of force, particularly when it involves acceleration, is difficult. To curb the problem identified, laboratory practical activities was employed. Sixty-two second year students of St. James Seminary/Senior High School in the Sunyani Municipality in Bono Region were purposively sampled into experimental and control groups. The experimental group was taught using laboratory practical activities as instructional technique and the control group using traditional method of teaching. Two research questions and a hypothesis were raised in the study. The instruments were pre-test and post-test, practical activities, observation and questionnaires for both the experimental and control groups. Data collected were analysed using simple frequency, z-test and descriptive statistics. The findings revealed that students exposed to frequent laboratory practical activities performed better than those exposed to traditional method of teaching. The findings from the research also indicated that students in the experimental group confidence increased from lesson to lesson. The study recommends that physics teachers take students through a lot of more laboratory practical activities, since this will help students' gain better understanding of the concept and improve their academic performance.

Keywords: Force, Laboratory Practical Activities, Physics, Technical Support, Teaching/Learning Materials

INTRODUCTION

Physics is one of the branches of science that deals with the study of energy and its interactions with matter. According to Hazari, Potvin, Lock and Lung (2013), physics is more than a part of physical sciences. It is the basis of science. An understanding of science begins with understanding physics. The study of physics, therefore, is to enable students to learn about the present and be able to project into the future from the present. Physics is not a subject to be studied in abstraction, especially at the senior high school level.

The study of forces like any other physics topic involves the use of the senses. Every day we see things that do not continue in a constant state of motion. Objects initially at rest later may move; moving objects may follow paths that are not straight lines and things in motion may stop. Most of the motion we observe undergoes changes and is the result of one or more applied forces (Hewitt, 2015). In physics, however, we are not concerned with these less precise meanings, but with the purely scientific and mechanical aspects of force, with force defined as a push or a pull which tends to cause a change in motion (Giancoli, 2010).

Source of force may be gravitational, electrical, magnetic, or simply muscular effort. Forces can be put into two categories, namely contact and action-at-a-distance (field) forces (Owusu & Baiden, 2010). According to Cutnell, Johnson, Young and Standler (2015), contact forces are those types of forces that result when two interacting objects are perceived to be physically contacting each other. Examples of contact forces include frictional forces, tensional forces, normal forces, and air resistance forces. Field forces are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. The Sun attracts the Earth through gravity, without the Earth ever coming into contact with the Sun. Physicists also call forces of gravity no-local, because the forces appear to affect objects that are not in the same location, but at a distance from one another (Spolter, 2014; Cutnell, Johnson, Young & Standler, 2015; Bensky, 2016)

Force of gravity is the silent force that keeps our feet on the ground. It also prevents the Earth and the stars from disintegrating, and holds the solar system and the galaxy together. Gravity is the attractive force that binds together the solar system, keeps the earth and the planets in orbits, and prevents the stars from exploding. Force of gravity causes fruits to fall to the ground. Electromagnetic force lights up our cities. Lasers, radio, television, computers, the internet, electricity all are consequences of electromagnetic force. The electromagnetic force holds together the atom. It makes the electrons orbit around the positively charged nucleus of the atom. All forces are important. (Spolter, 2014; Cutnell, Johnson, Young & Standler, 2015; Bensky, 2016). Without one we could not live.

Forces are in our everyday lives even though we may not know it. Students' views about a course influence their understanding and learning of that course. Many students think and say "force is difficult". Students' difficulties stem from force concepts, the way in which the topic is taught.

One of the essential methods that might be employed to enhance the understanding of scientific principles and the development of the scientific inquiry abilities required for investigations is the use of laboratory practical activities in science education. Practical science laboratory work has been accorded a central and specific location in science education for more than a century. According to science educators, implementing laboratory practical activities can have a significant positive impact on learning. The uniqueness of laboratory practical work, thus primarily consists in giving students opportunity to engage in the processes of study and inquiry (Millar & Abraham, 2009; Said & Friesen, 2014).

A practical activity is a didactic method for learning and practicing all the activities involved in carrying out practical inquiry relevant for one's profession. Physics practical experiments do not only enhance the learning experiences but also help students achieve lifelong learning skills, including problem solving skills which are essential to practical works in scientific fields. According Babalola, Lambourne and Swithenby (2020), the relationship between experiments, laboratory work is in turn a subset of practical activities, which in turn is a subset of the physics education curriculum. This implies experiments, laboratory works, and practical activities are all strategies designed and tailored to achieve the aims and objectives of the physics curriculum.

Observation of students' exercises and interview of a cross-section of the students revealed that force was too much of an abstract concept, too theoretical and full of calculation. Also, after conducting interviews with some physics teachers in the St. James Seminary/Senior High School, it was noted that they were still hesitant to teach the practical aspect of forces in their day-to-day classroom activities. They claimed that it was time consuming, in terms of taking away part of the teacher-talking time, and students' practice-time as well. They also believed that practical activities distracted students from focusing on the main concepts to be learned.

This study therefore investigated the effect of laboratory practical activities on senior high school students' academic performance in relation to force concept. It was focused on the unit of forces, which was taught to form two science students of St. James Seminary/Senior High School.

Purpose of study

The purpose of this study was to use laboratory practical activities technique to help improve form two science students of St. James Seminary/Senior High School performance in solving problems related to forces.

Objectives of the research

1. To determine the conception of forces held by science students of St. James Seminary/Senior High School.
2. To determine the learning habits exhibited by science students of St. James Seminary/Senior High School in learning of forces before and after the introduction of laboratory practical activities method as an intervention

Research questions

1. What are St. James Seminary/Senior High School science students' conceptions of forces?
2. What were the learning habits exhibited by the form two science students of St. James Seminary/Senior High School before and after the introduction of the laboratory practical activity as an intervention?

METHODS

The study was quasi experimental research design with mixed quantitative and qualitative data. This research design made use of practical work in teaching force as an intervention, and the use of pre-and post-treatment test as well as students' questionnaire items. The design helped the researcher to use questionnaire to objectively measure how the students perceive the effectiveness of practical work during lessons.

The results of the post intervention test aided the researcher to test hypotheses on the performances of both the experimental group and the control group. The experimental students' responses to the questionnaire items were used to discuss and analyze the perceptions of the effectiveness of practical work in the teaching and learning of physics in schools.

The purpose was to get a sample size of thirty-one students as those within the lower scores limit in the pre-intervention test as the experimental group, and the remaining thirty-one with the higher scores limit as the control group. The experimental group consists of students whose scores in the pre-test fell below 50%. The modal age of the participants was 16years.

Treatment

Two instructional techniques were used to teach students over a period of one term. Students were taught one topic in each of the months in the term. Practical work was the main instructional technique used in teaching the topics in the experimental group. The students were actively involved in setting up the equipment and apparatus used in the laboratory, during the practical activities. This was to help students in acquiring science process skills. After each experiment, there was intensive class interaction and discussion led by the class teacher. Experimental procedure, data collection, manipulation and analysis procedure were always reviewed in the class before the students were required to complete writing the laboratory reports. The instruction in the control group did not stress much on practical work. Most content in this group was theoretically covered. Teacher demonstrations were the standard way of showing the learners the practical aspects of the topics.

Intervention activities

In the first activity, the experimental group were sent to the physics laboratory. They were supplied with centrifuge, test tube, chalk powder and water. The experimental group was divided into small groups. Students were given the test tube, water and the chalk powder. They were asked to mix the chalk powder and the water in the test tube. The students were then asked to separate the mixture using the centrifuge. The researcher asked questions based on the activity, of which some of the students said large forces known as centripetal forces were generated on the particles by whirling them round. The forces were greater on the massive particles.

It was pointed to them that, in the process of whirling it round, the force on the particles at the bottom of the test tube becomes greater as the speed increases. This is due to the radial centripetal force which is exerted on the contents of the tube. The liquid pressure at the bottom then becomes greater than at the open end. The pressure difference then causes the particles to settle in a way that the more massive ones are at the bottom of the tube. Students were quizzed to find out if they understood the direction in which this force acted and the term centripetal force was explained to them. They understood that an object moving in a circular track experiences centripetal force.

In the second activity, students were provided with masses, beaker, water and spring balance. They were asked to find weight of the masses in both air and water using the spring balance. It was found out by the students that the weight of a mass in the water was less than the weight in air. The term upthrust was explained to them.

They were also provided with stop watches, ball bearings, measuring cylinders and different liquids to determine friction in liquids. The control group was taught without laboratory practical activities, using the lecture method.

RESULTS AND DISCUSSION

Pre intervention observation

The researcher found out from observation that students' participation in class especially during force lessons was not encouraging. Students participated poorly in discussions during lessons and gave unscientific responses to questions posed. Most students had very low marks in class with few students showing interest in the lessons. Questionnaires were administered to students to find out their reasons for their poor behavior during force lessons.

The discussion of the results focuses on answering the research questions.

Research question 1: What is St. James Seminary/Senior High School science students' conceptions of forces?

This question was answered by questions 1, 2,3 and 4 of students' pre-intervention questionnaire.

Table 1: Students' perception of force

Items	SA		A		N		D		SD	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1. The study of force is relevant	2	3.23	7	11.29	4	6.45	16	25.81	33	53.23
2. I enjoy studying force	2	3.23	3	4.84	1	1.61	35	56.45	21	33.87
3. I often find myself studying force during my free time	1	1.61	2	3.23	8	12.90	23	37.10	28	45.16
4. I dislike force	18	29.03	31	50	9	14.52	2	3.23	2	3.23

Key: Strongly Disagree (SD), Disagree (D), Uncertain (NS), Agree (A) and Strongly Agree (SA).

Table 1 indicates the responses given by students from questions 1, 2, 3and 4 of students' questionnaire. In their responses, majority of the participants (79.04%), gave a negative (strongly disagreed and disagree) response with item 1, which indicates that the study of force is relevant. About 90.32% of the participants disagreed and strongly disagreed with item 2, which states that they enjoy studying of force whereas about 8.27% (strongly agree and agree) said they enjoy studying force. The item 3 of the students' pre-intervention questionnaire which indicates they often find themselves studying force during their free time was negatively (strongly disagreed and disagreed) responded by the participants (82.26%). Majority of the participants (79.03%) gave a negative response with item 4, which indicates` that, they dislike force.

From the above table it can be explained that most students had in mind that force involves many calculations and proofs which made it very difficult in learning. Besides they were taught using the lecture method. The lecture method resulted in making the topic complex to relate to the physical things around them. Learners hold a wide range of beliefs on basic concepts in science, and beliefs learners hold of the natural world tend to be naive, unstudied, and intuitive.

Research question 2a: What were the learning habits exhibited by the form two science students of St. James Seminary/Senior High School before the introduction of the laboratory practical activity as an intervention?

This question was answered by the question 5 of the students' questionnaire.

I rarely skip force lessons.

From the students' responses, majority of them felt comfortable when they missed force lessons, students faced difficulties in understanding basic concepts in force lessons and therefore would avoid it, if they had the option. Students found force lessons boring because force concepts are normally taught in abstract manner.

Summary of pre-intervention analysis

Through observations, exercises and questionnaire, it was observed that students' views about a course influence their understanding and learning of the course. Many students think and say force is difficult because they have to contend with different representations such as experiments, proofs, formulae, calculations, graphs and conceptual explanations at the same time. These requirements at one time are too many, and make it difficult for them to understand their lessons.

Majority of students also did not enjoy force lessons because teachers did not involve them in any activities. This resulted in boring lessons. They said they often sat and looked at the teacher without any contribution from them. There were no activities for students to enhance their understanding. Most of their force lessons were taught through the theoretical lecture method. Students could not picture what they were taught. This meant that they saw it to be abstract, making it difficult for them to relate what they were being taught to real life situations.

A pre-intervention test was also organised for both the control and the experimental group. This informed the researcher that majority of the sampled students who took part in the pre-intervention assessment test had difficulties in solving questions related to force.

Research question 2b: What are the learning habits exhibited by science students of St. James Seminary/Senior High School in learning of forces after the introduction of the laboratory practical activities as an intervention?

This question was answered by items 1, 2, 3 and 4 of the students' questionnaire on how students in the two groups participate in classroom during force lessons.

Table 2: Students participation during force lessons

Statement	Experimental group				Control group			
	N (N,%)	S (N,%)	O (N,%)	A (N,%)	N (N,%)	S (N,%)	O (N,%)	A (N,%)
1. Asking question/answering questions	1 3.23	2 6.45	7 22.58	21 67.74	14 45.16	11 35.48	5 16.13	1 3.32
2. Seeking clarification on areas not understood	2 6.45	2 6.45	5 16.13	22 70.97	17 54.84	11 35.48	1 3.23	2 6.45
3. Volunteer to perform a task during a lesson	2 6.45	1 3.23	4 12.90	24 77.41	20 64.52	7 22.58	2 6.45	2 6.45
4. Participating in group work activity/discussion	1 3.23	3 9.68	6 19.35	21 67.74	16 51.61	13 41.94	1 3.23	3 9.68

Key: Never(N), Sometimes (S), Often(O) and Always(A).

Table 2 indicates that the experimental group had students (67,74%) ask and answer questions above average compared to the control group (3,23%). Alter going through the course, 70,97% of the experimental group respondents reported that they seek for clarification on area not understood during force lessons compared to only 6.45% of the control group. Only 6.45% answered that they do not seek for clarification on area not understood by them in the experimental as compared to 54.84% in the control group. About 35.48% in the control claim they were doing it in a minimum way compared to 6.45% in the experimental group. Some 67.74% of the students in the experimental group claim that they actively participated ingroup work activity and discussion whilst only 9.68%

of the students in the control group said they actively participate in group work activity and discussion.

The issue of students volunteering to perform a task during lesson also favoured the experimental group. The experimental group had 77.41% of the respondents indicating that volunteering to perform task during lessons compared to only 6.45% of the control group.

Observation

It was observed that the students in the experimental group participated and contributed effectively during the lesson as compared to the students in the control group. The students in the experimental group were able to explain force and its applications. They were happy with the lessons when the activities were introduced and grasped the concept easily.

The pre-intervention observation revealed that the students in both the experimental and the control groups often left the class during the force lessons but the same students in the experimental group were always present in the class when laboratory practical activities were being organised and performed. They were all involved and every student played a role in the activities. It was observed that, students in the experimental group continued to learn force even when it was time for break. Practical work can increase students' sense of ownership of their learning and can increase their motivation. Practical work gives students the opportunity to exchange views and share personal experiences. Laboratory practical activities provide students with insight into scientific practice and can increase interest in science and motivation to continue its study. Another attitude observed was the students' seriousness. They paid attention and tried to follow instructions given to them. With the use of the laboratory practical activities, the students in the experimental group were always punctual for force lessons. Their participation in class changed, which led to improvement of their understanding in the concept of force.

Post-intervention analysis

The use of laboratory practical activities and involvement of students in the experimental group during force lessons showed a great improvement in the students' performance in the experimental group contributions in class as compared to the students in the control group. Post-intervention questionnaires and post-intervention test given to students were analysed.

Pre-test and post-test analysis

Table 3: Group Performances in the pre and post tests

Group	Type of test	No. of respondent (N)	Mean performance (%)	Standard deviation	z-test	p-value
Experimental	Pre-test	31	34.94	13.74	-8.47	0
Control	Pre-test	31	62.29	11.61		
Experimental	Post- test	31	67.13	10.19	4.40	5.32×10^{-6}
Control	Post- test	31	51.45	17.00		

The experimental and the control groups had mean performances of 34.94% and 62.29% respectively on the pre-test. The result clearly shows that there is significant difference in the performance between the two groups at the beginning of the study. The result indicates that the two groups were not comparable on their initial understanding of the taught concepts in the study of physics in the first year.

Therefore, the z-test analysis of the pre-test for both groups shows the existence of a significance difference between their mean scores as seen from table 3 ($z=-8.47$; $p<0.05$).

Table 3 shows an increase in mean performance from 34.94% in the pre-test to 67.13% in the post test by the experimental group as compared to a decrease in mean performance from 62.29% in the pre-test to 51.45% in the post test by the control group. This indicates that the experimental instructional technique was having a positive effect on the respondents' direct understanding on the items post-test. The respondents were developing a focused view point about the task requirement after the instruction. Since the experimental and control groups were more than thirty, the z-test was used to determine significance of difference of the mean from the post-test.

Therefore, from Table 3, z-test analysis of the mean score on the post-test shows no significance difference ($z = 4.40$ and $p > 0.05$) in performance between the two groups. The experimental group demonstrated a better conceptual understanding of the taught force concept with the use of laboratory practical activities, which was reflected their post-test mean score value the intervention.

Testing null hypotheses

There is no significant difference in performance between the students in the experimental group taught using practical work and the control group students.

A-tailed z-test was employed for the verification of the test mean scores of the experimental and the control groups. It was observed that the calculated z-value ($z=4.40$; $p>0.05$), was not significant at a probability level of 0.05 as shown in Table 3.

Statistically, the null hypothesis is accepted at 95% confident level because the use of practical work had been able to raise the performance of the experimental group.

The analysis indicates that on the average, students in the experimental group performed better than students in the control group. In their study on the use of practical work method in teaching science, Abrahams and Millar (2008) observed that the use of practical work method yielded better results among the learners. They noted that this method has the advantage of allowing learners to conceptualize the knowledge learnt.

After the intervention, the students in the experimental group themselves called for class exercises, class test and homework. They found assessment exercises as a means to exhibit what they had learnt. Students in this group wanted more force lessons even during free periods. Students' absence from force lessons was a thing of the past as compared to those in the control group. These were a clear indication of students' change in attitude towards force and its assessment exercise.

CONCLUSION

A critical look at the research findings portrayed the causes of poor performance in force and how it could be improved. Teaching methods employed by physics teachers affect students' learning of force. Whether their interest will be sustained or not will depend on the method of teaching. Laboratory practical work has the potential of promoting and maintaining students' interest in learning of physics since it makes the learning process more real and easy to comprehend by learners.

The use of laboratory practical activities during instructional periods resulted in a major change in the attitude towards force by the experimental group as compared to the control group. The experimental group recorded positive responses in all the investigated studies Which is an indication that the use of the laboratory practical activities has impacted positively in their attitudes toward force and physics in general. Most of the students in the experimental group agreed that they could apply the topics learnt in their daily life activities as compared to a hand full of students in the control group.

Engaging the experimental group in the laboratory practical work contributes to improved performance in the topics from which the practical activities were derived. Discussing the results obtained from the practical session and guiding the group to draw their own conclusions allowed the students to develop better understanding of force. The understanding of force was founded on a personal experience rather than on theoretical imposition.

Recommendations

Findings in the previous section, the researcher made the following recommendations.

1. Physics teachers should seek ways of encouraging and motivating students during the physics experiment lessons, for example, in volunteering to perform a task, in suggesting possible outcomes to the experiments, and in improvising materials to perform experiments.
2. Further on, the students should be encouraged to perform and carry out experiments outside normal class work under supervision. School laboratories should be made available to students
3. It would be necessary for physics teachers to adopt the use of practical work as a technique in teaching so as to solve the problem of many students under performing in physics at the secondary school level. Since the use of laboratory practical work in teaching have the ability to raise and maintain students' interest in the studying of force and also developing their science process skills.

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