The Effectiveness of Constructivist Approach-Based Experiments in Teaching Selected Physics Concepts

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Abstract

The purpose of this study was to develop constructivist approach-based experiments and to determine its effectiveness in teaching some physics concepts in mechanics.

In the conduct of the study, the quasi-experiment following a non-equivalent control group design was used. The study started with the administration of pre-test and attitude inventory test. The teaching making use of constructivist approach-based experiments for the experimental group and traditional experiments for the control group followed. Finally, it ended with the administration of the post-test and attitude inventory test.

The control group and the experimental group were equal in terms of cognitive level in physics. However, the students exposed to the constructivist approach had significantly higher post-test scores and higher mean gain scores than the students exposed to traditional approach. The study also revealed that the experimental group developed a more positive attitude towards physics than the control group. There was a significant difference between the post achievement scores of the students exposed to constructivist approach-based experiments and traditional experiments.

As revealed in the study, the Constructivist Approach-Based Experiments are effective in enhancing students' achievement and in developing a more positive attitude towards physics than the Traditional Experiments. Furthermore, the students' achievement and attitude towards the subject can be intensified when they work cooperatively, providing them with more opportunities to apply their own skills and make their own decisions thus overcoming their misconceptions on the subject.

The constructivist approach-based experiments really affirmed its worth and advantage as instructional material in teaching physics concepts.

Keywords: Constructivist Approach; Constructivist Approach-Based Experiment;, Traditional Experiment;, Attitude Towards Physics

I. INTRODUCTION

Science is recognized widely as being of great importance internationally both for economic well being of nations and because of the need for scientifically literate citizenry (Fraser & Walberg, 1995). Among the basics of science, physics is the most fundamental and all-inclusive of all the sciences. It is one of the subjects that needs careful re-examination to determine what improvement could be made to fully develop the students' potentials in the subject. The study of Physics involves the pursuit of truth, hence it inculcates intellectual honesty, diligence, perseverance and observation in the learners (Das, 1985). It's being tagged as a difficult subject is almost a prophetic statement as shown in the performance of the Filipino students in various international assessments. Ganagen (2000) said that no subject in the curriculum today has drawn greater attention than science. But sad to know that the present state of science education as assessed by renowned scientist both in local and international circles are "discouragingly poor".

In the different science subject areas, achievements in physics of Filipino students appeared below the international standards (US Department of Education National Center for Education Statistics 2000, International Association for the Evaluation of Educational Achievement 2004). The Philippines ranked third and fourth to the last in the list of nations in the 1999 and 2003 TIMSS respectively. Findings of Philippine-based studies (Orleans 1994) also present the same conclusion of low student achievement in physics. This poor student achievement has prompted educational researchers worldwide to continuously identify factors that can account for academic outcomes in the classroom. Considering the worth of knowing physics, it becomes a challenge for teachers how they could make physics teaching more attractive to the students.

Student's misconceptions in science, specifically in physics are just but common and universal in scope. After conducting a review of literature and extensive reading, the researcher found out that one of the approaches or strategies in teaching which take into consideration the misconception of the students is the constructivist approach. According to Novodvorsky, constructivism is a philosophy of learning that covers all classroom activities, thus, it is also applicable in the performance of experiments in the laboratory. Because of this, the researcher was encouraged to develop selected experiments in physics specifically in mechanics based on the constructivist approach for the purpose of identifying and overcoming the student's misconceptions on some of the most basic concepts in mechanics.

The constructivist approach was utilized in this study. It is the researcher's desire to test the effectiveness of the constructivist approach-based experiments in teaching and learning selected physics concepts.

Specifically, this study was conducted to:

1. Determine the significant differences between the control group and experimental group in terms of the following:
   a. pre-achievement scores
   b. post-achievement scores

c. pre-attitude scores towards physics
d. post-attitude scores towards physics
e. gain scores

3. Determine the significant difference between the achievement and attitude scores towards physics before and after the study of the:
   a. Experimental group
   b. Control group

II. METHODOLOGY

The researcher used a quasi-experiment following a non equivalent control group design to verify the effectiveness of the constructivist approach-based experiments. It involved the comparison of concept learning in physics between students exposed to constructivist approach-based experiments and those to traditional experiments. The students that were exposed to constructivist approach-based experiments were designated as experimental group and those students that were exposed to traditional experiments were designated as control group. The students' achievement and attitude scores towards physics before and after the experiments were gathered and measures were employed.

The research was conducted at Isabela State University-Cauayan Campus, San Fermin, Cauayan City, Isabela, Philippines during the 2nd semester, SY 2008-2009. The respondents of the study were the two sections of the second year BSIT students wherein the researcher was assigned to teach Physics 11.

This research made use of the following data gathering instruments:

a. The Pre and Post Achievement Test
b. The Attitude Inventory Test (by Melecio Deauna)
c. The Traditional Experiments
d. The Constructivist Approach-Based Experiments

Before the experimental study, the pre-achievement test was administered to the two groups of respondents to find out their preconceptions and misconceptions in mechanics and likewise to measure their achievement level. The Deauna's Attitude Inventory test was also administered to determine the initial attitude level of the students towards physics.

The treatment for the experimental group differs from that of control group in only one aspect. During the period of study, the experimental group was exposed to the constructivist approach of laboratory teaching.

At the end of the study, a post achievement test was again administered to measure the achievement level of the students and the attitude inventory test was administered again to find out their post-attitude towards physics.

The t- test was used to determine if there was difference between the experimental and control groups in their:

a. Pre-achievement scores in physics
b. Pre-attitude towards physics
c. Post-achievement scores in physics
d. Post-attitude towards physics

III. RESULTS AND DISCUSSIONS

A. The Difference Between the Pre- Achievement Scores of Experimental and Control Groups

The pre-achievement test was conducted to find out if both groups of respondents posses the same cognitive level before the conduct of the study.

Table 1 shows the difference between the pre-achievement scores of the two groups of respondents.

It can be gleaned from the table that the experimental group had a pre-test mean score of 14.65 and a standard deviation of 4.02 while that of the control group had a mean score of 14.13 and a standard deviation of 3.41. The t-ratio of 0.671 has an associated probability of 0.252. This means that the null hypothesis is accepted. Hence, there is no significant difference between the pre-test mean scores of the two groups of respondents. This only means that the two groups of respondents have the same cognitive level before the study was conducted.

TABLE I. THE DIFFERENCE BETWEEN THE PRE-AACHEVEMENT SCORES OF EXPERIMENTAL AND CONTROL GROUPS

Group	Mean	SD	df	t-ratio	p
Experimental Group	14.65	4.02	90	0.671^{NS}	0.252
Control Group	14.13	3.41			

B. The Difference Between the Post-Achievement Scores of Experimental and Control Groups

After the study, the effect of constructivist approach and traditional approach in physics laboratory teaching was determined. The actual scores of the two groups were treated.

Table 2 shows the difference in the post-achievement scores of the experimental and control groups.

As shown in the table, the students exposed to constructivist approach-based experiments had a post-test mean score of 28.91 and a standard deviation of 3.60 while the group exposed to traditional experiments had a mean score of 22.52 and a standard deviation of 4.28. The t-ratio of 7.7464 has an associated probability of 6.79×10^{-12}. This means that the null hypothesis is rejected. Hence, there is a significant difference between achievement scores of the two groups after the study.

After the treatment, the two groups of respondents varied statistically in terms of their physics achievement. It also signifies that constructivist approach-based experiments as a tool in teaching laboratory physics did enhance better achievement of students than the traditional experiments.

The higher post-achievement score of the experimental group can be attributed to the fact that the students were highly motivated to play an active part in their acquisition of knowledge giving them an active role in their own learning. The ability of the students reconstructs their view of the physics world and extend their capacity to think rationally about it made them perform better academically after the study.

TABLE II. THE DIFFERENCE BETWEEN THE POST-ACHIEVEMENT SCORES OF EXPERIMENTAL AND CONTROL GROUPS

Group	Mean	SD	df	t-ratio	P
Experimental Group	28.91	3.60	90	7.7464^{S}	6.79×10^{-12}
Control Group	22.52	4.28			

C. The Difference Between the Gain Scores of Experimental and Control Groups

After the administration of the post-achievement test, the gain scores of the two groups were compared.

Table 3 shows the difference in the gain scores between of the experimental and control groups.

The mean gain score of the experimental group was 14.26 and a standard deviation of 5.43 while that of the control group was only 8.39 and a standard deviation of 5.53. The table also reveals that the t-ratio of 5.13 has an associated probability of 8.1×10^{-7} which means that there is a significant difference between the gain scores of the two groups after the study.

Furthermore, it can be noted that the students exposed to constructivist approach-based experiments gained more in their achievement scores after the conduct of the study. This is due to the approach of instructions in which the students had been exposed to.

The Constructivist approach of teaching laboratory physics using constructivist approach-based experiments resulted to an improved learning in physics which led to a better understanding of physics concepts. This implication can be due to the fact that in the constructivist approach, misconceptions on physical concepts and overcoming them are taken into consideration thus giving more emphasis on most aspects of concept attainment in physics for clearer and better understanding.

TABLE III. THE DIFFERENCE BETWEEN THE GAIN SCORES OF EXPERIMENTAL AND CONTROL GROUPS

Group	Mean	SD	df	t-ratio	P
Experimental Group	14.266	5.43	90	5.13^{S}	8.1×10^{-7}
Control Group	8.39	5.53			

D. The Difference Between the Pre-Attitude Scores Towards Physics of the Experimental and Control Groups

Before the experiment, the attitude scores towards physics of the students were determined using the Deauna's Attitude Inventory Test. This was done in order to find out if both groups of students have the same level of attitude towards physics before the conduct of the study.

Table 4 shows the difference between the pre-attitude scores towards physics of the experimental and control groups.

As gleaned from the table, the experimental group had a mean score of 3.459 and a standard deviation of 0.295 which means that they have a neutral attitude towards physics. The control group had a mean score of 3,400 and a standard deviation of 0.281 which also means that they have a neutral attitude towards physics.

The ratio of 0.9456 has a probability of 0.1734 which tells us that the null hypothesis is rejected. There is no significant difference between the pre-attitude mean scores of the two groups. This only means that the initial attitude of the two groups of respondents were the same before the conduct of the study.

TABLE IV. THE DIFFERENCE BETWEEN THE PRE-ATTITUDE SCORES TOWARDS PHYSICS OF THE EXPERIMENTAL AND CONTROL GROUPS

Group	Mean	SD	df	t-ratio	p
Experimental Group	3.459	5.295	90	0.9456^{NS}	0.1734
Control Group	3.400	0.281			

E. The Difference Between the Post-Attitude Scores Towards Physics of the Experimental and Control Groups

The post-attitude scores towards physics of the two groups of respondents were determined after the conduct of the study in order to find out if there was a significant change in the attitude of the students towards physics as a result of constructivist and traditional approach of teaching laboratory physics.

Table 5 shows the difference between the post-attitude scores of the experimental group after being exposed to constructivist approach-based experiments and the control group after being exposed to traditional experiments.

The table reveals that the post-attitude mean score of the experimental group was 3.88 and a standard deviation of 0.339 which means that their attitude towards physics was positive. This only shows that their attitude was changed significantly from the neutral before the conduct of the study to positive after the conduct of the study.

The table also reveals that the post-attitude mean score of the control group was 3.95 and a standard deviation of 0.336 which means that they still have a neutral attitude towards physics after the conduct of the study.

Furthermore, the t-ratio of 4.14 which has a probability of 3.85×10^{-5} means that the null hypothesis is rejected. Hence, there is a significant difference between the post-attitude of the experimental and control groups.

The above discussion implies that constructivist approach-based experiments enhanced the interest and attitude of the students towards physics better than the traditional experiments. The positive response of the experimental group after the study means that the students learned to appreciate and love physics. This can be attributed to the fact that since constructivist approach-based experiments give the students maximum opportunities to apply their own decision, they were more motivated in performing the activities that served to focus and stimulated their attention towards the lesson; hence a positive attitude that favors learning is nurtured.

TABLE V. THE DIFFERENCE BETWEEN THE POST-ATTITUDE SCORES TOWARDS PHYSICS OF THE EXPERIMENTAL AND CONTROL GROUPS

Group	Mean	SD	df	t-ratio	p
Experimental Group	3.88	0.339	90	4.14^{S}	3.85×10^{-5}
Control Group	3.59	0.336			

F. The Difference Between the Pre and Post Achievement Scores of the Students Exposed toConstructivist Approach-Based Experiments

The pre and post achievement test were administered in order to determine whether was a significant change on the achievement of the students as a result of using constructivist approach-based experiments as a tool in teaching laboratory physics.

Table 6 shows the difference between the pre and post achievement scores of the experimental group.

Before the conduct of the conduct of the study, the mean score of the students was 14.65 with a standard deviation of 4.02 which was increased significantly to 28.91 with a standard deviation of 3.60 after the conduct of the study.

The table also reveals that the t-ratio is 17.91 which has a probability of 9.5 x 10^{-14} which has a probability of 9.5 x 10^{-14} which means that the null hypothesis is rejected. Hence, there is a significant difference between the pre and post achievement scores of the students exposed to constructivist approach-based experiments. It also suggest that constructivist approach based experiments as a to0l in teaching laboratory physics did enhance achievement. The students performed better as a positive effect of the approach that was employed.

Furthermore, it was also observed that during the conduct of the study, students showed willingness to undertake new tasks, initiative new ideas related to classroom activities, project and adapt easily to changes in procedures.

TABLE VI. THE DIFFERENCE BETWEEN THE PRE AND POST-ACHIEVEMENT SCORES OF THE EXPERIMENTAL GROUP

Achievement	Mean	SD	df	t-ratio	p
PRE	14.65	4.02	45	17.91^{S}	$9.5x10^{-14}$
POST	28.91	3.60			

G. The Difference Between the Pre and Post Achievement Scores of the Students Exposed to Traditional Experiments

The pre and post achievement test were administered in order to determine whether there was a significant change on the achievement of the students as a result of using traditional experiments as a tool in teaching laboratory physics.

Table 7 shows the difference in the pre and post-achievement scores of the control group.

The table reveals that the students in the control group obtained a pre-test mean score of 14.13 with a standard deviation of 3.41 and a post-test mean score of 22.52 with a standard deviation of 4.28. The t-ratio of 10.395 which has a probability of 2.0 x 10^{-14} tells us that there is a significant difference between the pre and post achievement scores of the students exposed to traditional experiment.

The result presented in the table implies that there was a significant increase in the mean scores of the students after the conduct of the study. This means that traditional experiments are also capable of improving the student's performance in physics and should not be discarded as one of the approaches employed to be employed in physics laboratory teaching.

In the event of the study, it was observed that students were also participative and enthusiastic in performing the activities which were undertaken in the subject.

TABLE VII. THE DIFFERENCE BETWEEN THE PRE AND POST-ACHIEVEMENT SCORES TOWARDS PHYSICS OF THE CONTROL GROUP

Achievement	Mean	SD	df	t-ratio	p
PRE			45	6.47^{S}	$2.49x10^{-9}$
POST					

H. The Difference Between the Pre and Post Atitude-Scores of the Students Exposed to Constructivist Approach-Based Experiments

The Pre and Post-Attitude Inventory Test were administered in order to determine whether there was a significant change on the attitude of student's towards physics after employing the constructivist approach of laboratory teaching.

Table 8 shows the comparison of the attitudes towards physics of the students exposed to constructivist approach-based experiments before and after the study.

The students in the experimental group had a pre-attitude mean score of 3.46 with a standard deviation of 0.295 and a post-attitude mean score of 3.88 with a standard deviation 0f 0.339 and with a t-ratio of 6.47 with an associated probability of 2.49 x 10^{-9}. Thus, there is a significant difference between the attitude of the experimental group before and after the study.

The table further reveals that the students in the experimental grouped developed a positive attitude after the study.

The increase in the attitude mean scores indicates that the students who were exposed to constructivist approach-based experiments were well-motivated to love, like the subject, appreciate the interesting activities and show interest, eagerness and enthusiasm towards physics.

TABLE VIII. THE DIFFERENCE BETWEEN THE PRE AND POST-ATTITUDE SCORES TOWARDS PHYSICS OF THE EXPERIMENTAL GROUP

Achievement	Mean	SD	df	t-ratio	p
PRE	3.46	0.295	45	6.47^{S}	$2.49x10^{-9}$
POST	3.88	0.339			

I. The Difference Between the Pre and Post Attitude Scores of the Students Exposed to Traditional Experiments

The Pre and Post-Attitude Inventory Test were administered in order to determine whether there was a significant change on the attitude of students towards physics after employing the traditional approach of laboratory teaching.

Table 9 shows the difference between the pre and post-attitude towards physics of students exposed to traditional experiments.

It can be gleaned from the table that the pre-attitude mean score of the control group was 3.40 with a standard deviation of 0.2812 and after the study the attitude mean score was found out to be 3.59 with a standard deviation of 0.3364. The table further shows that the null hypothesis is rejected. Hence, there is a significant difference between the pre and post attitude mean scores of students exposed to traditional experiments.

Thus, it can be noted that traditional experiments can also enhance the students' attitude towards physics

TABLE IX. THE DIFFERENCE BETWEEN THE PRE AND POST-ACHIEVEMENT SCORES TOWARDS PHYSICS OF THE CONTROL GROUP

Achievement	Mean	SD	df	t-ratio	p
PRE	3.40	0.2812	45	3.0013^{S}	$1.74x10^{-3}$
POST	3.59	0.3364			

Hence, the developed constructivist approach-based experiments as a tool in teaching laboratory physics is an innovative approach that affects the students' achievement and attitude towards physics. The result of this study strongly supports the research findings of Arpilleda (1982), Alcantara (1982), Tong

(1993) and Camarao (1996) that the use of innovative approach of instruction in teaching physics greatly affects students achievement.

The result of this study also strengthens the theory of Tibigar (1986), Garcia (1989), Rafael (1990), Hidalgo (1991), Teeravarapang (1992), and Agara (1996) that effective science teaching is based on the teacher's arc of using any particular method in achieving goals. Innovative method and approaches improved learning and are helpful in developing the critical thinking among students. The approach of instruction should motivate the learner to strive to learn and to acquire knowledge to find something new to the world and explore for themselves. Based on the foregoing discussions, constructivist approach of laboratory teaching enhances better achievement and attitude towards physics.

CONCLUSION

Based on the findings of this study, the following conclusions were drawn:

1. The Constructivist Approach of laboratory teaching using Constructivist Approach-based Experiments is effective in enhancing student's achievement and in developing a more positive attitude towards physics than the Traditional experiments.
2. The students' achievement and attitude towards physics can be intensified when they work cooperatively as they learn; providing them with more opportunities to apply their own skills and make their own decisions; and taking into consideration as well as overcoming their misconceptions on the subject.

RECOMMENDATION

In the light of the findings and conclusion of this research, the following recommendations are hereby presented;

1. Since the use of constructivist approach in physics laboratory teaching resulted significantly to students learning in terms of knowledge, comprehension, application and analysis in physics, this approach therefore, is highly recommended as one of the many strategy/approaches a teacher can use in the classroom to motivate students and to produce better achievement in physics.
2. Teachers and laboratory manual writers should be encouraged to use and design more constructivist approach-based experiments.
3. Heads of academic institutions must be encouraged to sponsor or conduct seminars and trainings on constructivism using experts on the field as a part of their faculty development program.
4. A replication of the study by using bigger sample and more number of items in the achievement test providing more items on analysis, application and synthesis should be conducted to ascertain the same results.
5. Further researches must be done to test the effectiveness of constructivist approach-based experiments in teaching other topics or other science subjects.

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