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Physics Olympics: An Enhancement approach for Students' physics performance, critical thinking, and science process skills

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ABSTRACT

This quasi-experimental study aimed to determine the effect of the physics Olympics on Grade 7 students' performance, critical thinking, and science process skills. The participants were the Grade 7 regular class students of a rural public high school in Panay Island. The participants were divided into two groups; one group was exposed to an inquiry-based approach while the other was to an inquiry-based approach enhanced with Physics Olympics. It utilized validated researcher-made and adopted-modified instruments. The data underwent statistical and thematic analysis. The study found that both the inquiry-based approach and with Physics Olympics were effective in improving students' physics performance, critical thinking, and science process skills. Though both groups were categorized as approaching proficiency level in terms of physics performance and critical thinking skills, the mean gain among the students who were exposed to intervention was higher compared to that of the students who were exposed to the traditional approach. In terms of the science process skills, students who were exposed to the inquiry-based approach were at the approaching proficiency level while those who were exposed to the intervention were at the proficiency level. The two groups had no significant difference in their mean gain scores in physics performance and critical thinking skills after the intervention. However, their mean gain score in science process skills was statistically significant which emphasizes the edge of inquiry-based teaching enhanced with physics olympics over inquiry-based approach. It can be recommended that science teachers teaching basic education should integrate physics Olympics as a mode of enhancing inquiry-based teaching approaches.

KEYWORDS

critical thinking skills, inquiry-based approach, grade 7 learners, physics Olympics, science process skills

INTRODUCTION

Inquiry-based learning is the heart of the K to 12 curriculum with its aim to create a conducive and interactive student-centered classroom environment. The curriculum provides learners with a repertoire of competencies important in the world of work and in a knowledge-based society. Its primary objective is to equip learners with the necessary skills to become critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision-makers, and effective communicators. It was designed based on the three domains of learning science: understanding and applying science to local and global settings; carrying out scientific processes and skills and instilling among them scientific attitudes and values (K to 12 Science Curriculum Guide, 2016).

The science content and processes in the K-12 curriculum are intertwined and are organized around situations and problems that challenge and arouse students' curiosity and motivate them to learn and appreciate science as a relevant and useful subject. There are varied hands-on, minds-on, and hearts-on activities that are used to develop students' interests and stimulate them to become active learners instead of just relying solely on textbooks. In general, the K-12 science curriculum is learner-centered and inquiry-based, emphasizing the use of evidence in constructing explanations. Concepts and skills in Life Sciences, Physics, Chemistry, and Earth Sciences are presented with increasing levels of complexity from one grade level to another in a spiral progression, thus paving the way to a deeper understanding of the concepts. These concepts and skills are integrated rather than discipline-based, stressing the connections across science topics and other disciplines as well as applications of concepts and thinking skills to real life (Cabansag, 2014).

Physics as one of the disciplines in science is perceived by learners as uninteresting and difficult with the mathematical computations involved in solving worded problems (Ben, 2010). Alimen (2008) pointed out that students need to have a good grasp of the sciences. Furthermore, he stated that it has been identified that knowledge in physics has been a contributing factor for developed countries to prosper. It has even an impact on humanity. However, he also noted that students' attitudes and performance deteriorated in the last five years.

Philippine high school students manifested poor performance in some standardized tests including the National Achievement Test (NAT). The Department of Education (DepEd) reported that the NAT mean percentage score (MPS) for high school in the school year 2012-2013 was 51.41 percent or 23.59 percentage points away from the target National Passing Percentage. The MPS in science was 41.35 percent which is also 33.65 percent away from the target National Mean Percentage (Dela Cruz, 2017). Moreover, in the Trends in International Mathematics and Science Study (TIMSS) in 2008, the Philippines scored 355 and ranked 10th out of 10 participating countries. To answer the recent challenges in Science education, the K-12 curriculum has been an avenue for honing students' skills obtained through various learning activities (Cabansag, 2014). High school students must strengthen their conceptual knowledge of science while seeing the need to identify and develop their science process skills. Leonor (2014) pointed out that science process skills are inseparable in practice from conceptual understanding and should be discussed and identified because of their vital role in learning.

Critical thinking skills are another relevant skill in learning science. These are skills that require students to apply information in new situations and in solving problems. Critical thinking is an intellectually disciplined process that is characterized by creative conceptualization, application, analysis, synthesis, and evaluation of information collected from observations and experiences as a guide to belief and action (Ralston and Bays, 2013). With this, the challenge for the 21st century educators is to address the deterioration of students' performance in science. In this research study, it is perceived by the researcher that a positive change in perspective and an improvement should start by making the students interested in the discussion. It is important to emphasize to learners how important physics is as a subject because it encompasses everything around us. Its application is not only limited to the four walls of the classroom. The option is to integrate Physics Olympics which stimulates engaging teaching and learning. The activities involve the understanding and application of physics principles and the use of creativity. The mere exercise of skills or physical prowess is de-emphasized. The conduct of the Physics Olympics should continue as a fun and learning experience. While competition remains an essential element, the unitive aspect must prevail. After all, the Physics Olympics becomes meaningful only if it nurtures the growth of the physics community (Maxino, 2014). This study is anchored on the following theories: the theory of constructivism, discovery learning, and game theory. These theories believe that knowledge is acquired through an active and constructive process. Learners construct knowledge in their own unique ways. They use their personal experiences and undergo negotiation with others in evaluating such knowledge.

METHODS

This study employed a quasi-experimental research design to determine the physics performance, critical thinking, and science process skills of Grade 7 students who were exposed to an inquiry-based approach and physics Olympics. A quasi-experimental design according to Shuttleworth (2008) involves selecting groups, upon which a variable is tested, without any random pre-selection processes. This study employed quasi- quasi-experimental design since it compared means to determine the teaching strategy that would best improve learners' physics performance, critical thinking, and science process skills. This study involves a pretest-posttest design to compare participating groups and measure the degree of change occurring as a result of treatments or interventions. Pretest-posttest designs grow from the simpler posttest-only designs, and address some of the issues arising with assignment bias and the allocation of participants to groups. A quasi-experimental research is employed in this study since there is an existence of pre and post-treatment. The design is illustrated below.

O1	O2	O3	X1	O1’	O2’	O3’
O1	O2	O3	X2	O1’	O2’	O3’

Where:
X1 = Inquiry -based on Physics Olympics group
X2 = Inquiry-based group
O1 = pre-test scores in Physics performance
O2 = pre-test scores in critical thinking
O3 = pre-test scores in Science process skills
O1’= post-test scores in Physics performance
O2’ = post-test scores in critical thinking
O3’ = post-test scores in Science process skills

Subject of the Study

The subjects of this study were the two sections of grade 7 regular classes for the school year 2017-2018 in one of the secondary schools in the Municipality of San Enrique. The groups were chosen as the subjects of the study because of their availability. These sections were classified into experimental and control groups which was determined through a toss-coin technique. The experimental group was exposed to inquiry-based physics Olympics while the control group was exposed to inquiry-based alone. There were 76 participants, 38 for each group that were matched paired based on third quarter grade in Science. Other students who were not chosen as subjects received the same treatments that were given to their classmates. Furthermore, ten (10) of the 76 participants; five (5) from the inquiry-based group and another five (5) from the inquiry-based with Physics Olympics were purposively chosen to answer the questionnaires to understand their experiences from the intervention.

Research Instrument

A researcher-made performance test was used to measure the effect of an inquiry-based approach enhanced with Physics Olympics on Physics performance, adopted-modified critical thinking appraisal, and science process skills tests for the critical thinking and science process skills. These tests were constructed and modified to cover and test the subjects' performance, critical thinking, and science process skills in Grade 7 physics. A table of specifications was constructed for these tests. These tests were pilot-tested to establish their reliability and these all have reliability coefficients that were considered reliable. These were also validated by three experts coming from West Visayas State University, Iloilo State College of Fisheries, and the Department of Education. All these tests were implemented in the pre and post-test.

Physics Performance. The Physics Performance Test (PPT) is a 60-item test in Grade 7 science for the fourth quarter of the K to 12 curriculum. The resulting mean had the following scale:

Mean	Descriptive Rating
48.00 - 60.00	Advanced (A)
36.00 - 47.99	Proficient (P)
24.00 - 35.99	Approaching Proficiency (AP)
12.00 - 23.99	Developing (D)
1.00 - 11.99	Beginning (B)

For Beginning (B), the student at this level struggles with his/her understanding; prerequisite and fundamental knowledge and/or skills have not been acquired or developed adequately to aid understanding. For Developing (D), the student possesses the minimum knowledge skills, and core understandings, but needs help throughout the performance of authentic tasks. In Approaching Proficiency Level (AP), the student has developed the fundamental knowledge skills and core understandings and, with little guidance from the teacher and/or with some assistance from peers, can transfer these understandings through authentic performance tasks. In the Proficient (P) level, the student has developed the fundamental knowledge skills and core understandings and can transfer them independently through authentic performance tasks. In the Advanced (A) level, the student exceeds the core requirements in terms of knowledge, skills, and understandings, and can transfer them automatically and flexibly through authentic performance tasks (Dep Ed. Order no.31 s.2012).

Critical Thinking Skills. Critical thinking was measured using the Critical Thinking Appraisal Test (CTAT) patterned from the work of Gicole (2017) which was used to assess the critical thinking skills of Grade 9 students.

The Critical Thinking Appraisal Test (CTAT) is a 45-item test. The test is divided into five areas of critical thinking namely, Inference, Recognition of Assumptions, Deductive Reasoning, Interpretations, and Evaluating Arguments. For Inference, the test is composed of a passage describing a set of facts, followed by inferences. The students determined the truthfulness and falsity of the inference by circling the "T" for true "F" if the inference is false; and "I" if there is insufficient information to decide. For the recognition of the assumption, a passage or statement is given followed by several proposed assumptions. The students will determine whether the assumption is made or not made in the presented statements by encircling options "YES" or "NO". For deductive reasoning, conditional statements are given followed by conclusions. Students will decide if the conclusions logically follow beyond reasonable doubt from the information given in the paragraph. If the conclusion follows beyond a reasonable doubt, students will encircle "YES" if otherwise "NO". In evaluating arguments, questions are presented followed by arguments. Students will decide if the arguments are strong by encircling the word "STRONG" if otherwise "WEAK". The test was implemented in the pre and post-test. The perfect Critical Thinking Appraisal Test (CTAT) score is 40. The score obtained by the test taker is equal to the number of items correctly answered. The students' Critical Thinking Appraisal Test (CTAT) mean score was interpreted using the following scale (Dep Ed Order 31 s.2012):

Mean	Descriptive Rating
36.00 - 45. 00	Advanced (A)
27. 00 - 35. 99	Proficient (P)
18.00 - 26. 99	Approaching Proficiency (AP)
9.00 - 17.99	Developing (D)
0.00 - 8. 99	Beginning (B)

Science Process Skills. The science process skills were measured using the Science Process Skills Test adopted and modified on the work of Villanueva (2016). This test was used to assess the science process skills of fourth-year high school students. The test was modified to assess the science process skills of Grade 7 students. The test is a 27-item multiple-choice test. It consists of items measuring the students' basic and integrated science process skills, namely observing, measuring, classifying, quantifying, inferring, predicting, identifying relationships, communicating, interpreting data, controlling variables, defining operationally, hypothesizing, and experimenting.

The following scale was used to describe the subjects' science process skills (DepEd Order 31 s.2012):

Mean	Descriptive Rating
21.60 - 27.00	Advanced (A)
16.20 - 21.59	Proficient (P)
10.80 - 16.19	Approaching Proficiency (AP)
5.40 - 10.79	Developing (D)
0.00 - 5.39	Beginning (B)

Questionnaire. This assessed students' experiences when they were exposed to inquiry-based approaches and Physics Olympics.

Data Collection

The data-gathering procedure was divided into three stages: the pre-experimental stage, the experimental stage, and the post-experimental stage.

Pre- experimental Stage. A letter was sent to the principal asking permission to use the Grade 7 regular class students as the participants of the study. Another letter was sent asking permission to conduct pilot - testing of the instruments. The respondents were classified into experimental and control groups. Instruments used in this study were formulated and validated in this stage. After the validity and reliability test of the instruments, revision was done and a pre-test for Physics performance, critical thinking, and science process skills was conducted for both the experimental and the control group. Respondents were oriented about the study. Lesson plans that are intended for two different groups that utilized both the inquiry-based approach but differ in the enhancement activity and focus on the same topics in Physics were prepared and developed during this stage. Selection of the subjects that will be assigned to either inquiry-based or inquiry-based with physics Olympics was done through a toss-coin technique. *Physics Olympics*. The Olympics made by the researcher were related to the topics covered in the lesson. These activities were validated by the experts. There was one game to be conducted after the end of every topic. The students were divided into groups. This grouping was maintained until the end of the intervention. The scoring rubric was provided for the participants. The score obtained by each group in every game was recorded. Accumulation of points was done after the end of the last game. The group with the highest score was declared as champion, first runner-up, and 2nd runner up respectively.

Experimental Stage. This stage was approximately six weeks and the time for conducting the intervention. The two groups had the same lessons, references, and time allotment for each topic. The teacher-researcher employed the same strategy in delivering the lesson to both the experimental and control groups. However, each group received different enhancement activities. The experimental group was exposed to the Physics Olympics while the control group was to inquiry-based activities. To monitor the progress of each group, quizzes, recitations, responses, and performance tasks based on lesson guides were conducted. However, the assessment given after the class was similar to both groups, to ensure that all the other factors like topic, evaluation, and length of contact time were uniform except for the teaching strategies used. During the conduct of the study, the members of the research panel came and observed classes. They made sure that the study was conducted accordingly. Moreover, one science teacher continuously observed the classes during the intervention period. The schedule below was followed throughout the experimental period. Schedule of classes for two treatments

Treatment	Schedule
Inquiry-based approach	3:00 - 4: 00 PM
Inquiry-based enhanced with physics Olympics	2:00 - 3:00 PM.

Post Experimental Stage. After six weeks of intervention, the researcher conducted the post-test for Physics performance, critical thinking, and science process skills. Data gathered were subjected to statistical analysis and interpretation using Statistical Package for Social Sciences (SPSS).

Data Analysis

The data gathered in this study were subjected to appropriate descriptive and inferential statistics using the SPSS.

The tools that were utilized in interpreting the results of the study include the mean, standard deviation, independent samples t-test, paired samples t-test, and effect size. The mean was the computational average of a group of scores to determine the performance, critical thinking, and science process level of the Grade 7 students in Physics. The standard deviation was used to determine the dispersion of the Grade 7 students' scores from the means calculated from the Physics performance, critical thinking, and science process skills. The independent samples t-test was applied to the pre-test mean scores on the Test for Physics performance, Critical Thinking Skills Appraisal Test, and Science Process Skills Test of the Inquiry-based approach with the Physics Olympics group and Inquiry-based approach with inquiry-based activities group. This was also utilized to see whether the difference in the pre-test and post-test mean scores on the Test for Physics Performance, Critical Thinking Appraisal Test, and Science Process Skills Test of the experimental and control groups is significant. The paired samples t-test was used to determine whether the difference in the pre-test and post-test means of the experimental and control groups was significant. Lastly, the effect size is a test that was used to measure the strength of the effect of the intervention on the dependent variables.

RESULTS/FINDINGS AND DISCUSSION

Table 1. Pretest and posttest level in physics performance of experimental and control group

Group	n	SD	Mean	Description
Pre-Test				
Inquiry-Based Approach	38	4.41	15.79	Developing
Inquiry-Based Approach Enhanced With Physics Olympics	38	3.85	16.79	Developing
Post-Test				
Inquiry-Based Approach	38	5.30	32.92	Approaching Proficiency
Inquiry-based				
Inquiry-Based Approach Enhanced With Physics Olympics	38	5.29	33.87	Approaching Proficiency

Legend: 48.00-60.00-Advanced (A); 36.00-47.99-Proficient (P); 24.00-35.99-Approaching Proficiency (AP); 12.00 - 23.99 - Developing (D); 1.00 - 11. 99 Beginning (B)

The mean scores of the students in terms of Physics Performance were developing before intervention had been made (Inquiry-based approach $M = 15.79, SD\ 4.41;$ Inquiry-based approach enhanced with Physics Olympics $M = 16.79, SD = 3.85$). This developing level indicates that students possess the minimum knowledge and skills but need help throughout the performance of authentic tasks (K to 12 Curriculum Guide, 2013). Therefore, there is a need for students to undergo intervention. The standard deviation is nearly the same and there is a narrow dispersion of scores which indicates that the two groups are homogeneous in their pre-test physics performance. This agrees with the findings of the study of Arellano (2004) and Ebora (2016) that the majority of the students showed average performance in the achievement test in Physics. Thus, different approaches must be used by teachers in Physics to motivate the students and develop interest among them; there should be a sequence of activities that will lead to the discovery of concepts and laws in Physics. After the intervention, it was observed that those students who were exposed to inquiry-based obtained a mean score of (M=32.92, SD = 5.30) while those exposed to inquiry-based with physics Olympics obtained a mean score of (M= 33.87, SD = 5.29). The results revealed that students in both groups advanced their performance to Approaching Proficiency (AP). This tells us that students have developed the fundamental knowledge skills and core understandings and, with little guidance from the teacher and/or assistance from peers, can transfer these understandings through authentic performance tasks. This improvement in the level of student performance was due to the intervention that the teacher-researcher had introduced. There is an increase in the scattering of scores (inquiry-based approach SD 5.30; inquiry-based approach enhanced with Physics Olympics SD = 5.29 as compared to the pre-test (inquiry-based approach SD 4.41; inquiry-based approach enhanced with Physics Olympics *SD* =3.85). The standard deviation in the post-examination shows that there is a narrow dispersion of scores which means students in both groups are likewise homogeneous.

Table 2. Pretest and posttest levels in critical thinking skills of experimental and control group

Group	n	SD	Mean	Description
Pre-Test				
Inquiry-Based Approach	38	5.25	21.53	Approaching Proficiency
Inquiry-Based Approach Enhanced With Physics Olympics	38	4.10	21.55	Approaching Proficiency
Post-Test				
Inquiry-Based Approach	38	2.48	25.95	Approaching Proficiency
Inquiry-Based Approach Enhanced With Physics Olympics	38	3.64	26.42	Approaching Proficiency

Legend: 36.00-45.00-Advanced (A); 27.00-35.99-Proficient (P); 18.00-26.99-Approaching Proficiency (AP); 9.00 - 17.99 - Developing (D); 0.00 - 8. 99 Beginning (B)

The mean score of students in terms of critical thinking skills was Approaching Proficiency before intervention (with inquiry-based approach *M = 21.53, SD =5.25*; inquiry-based approach enhanced with Physics Olympics *M = 21.55, SD 4.10).* This tells us that students have developed the fundamental knowledge skills and core understandings and with little guidance from the teacher and/or assistance from peers, can transfer these understandings through authentic performance tasks. The standard deviation shows that the two groups are homogeneous in terms of their pre-test critical thinking skills. After the intervention, the mean scores in the post-examination revealed that all students still belonged to approaching proficiency level in terms of critical thinking skills despite an increase in the mean scores (inquiry-based approach *M = 25.95, SD=2.48;* inquiry-based approach enhanced with Physics Olympics *M = 26.42, SD = 3.64).* The result discloses that the students are approaching proficiency in terms of inferring, recognizing assumptions, reasoning deductively, and interpreting and evaluating arguments based on the given propositions, passages, statements, or conclusions. This tells us that students have developed the fundamental knowledge skills and core understandings and, with little guidance from the teacher and/or assistance from peers, can transfer these understandings through authentic performance tasks. This can be attributed to the fact that individuals are not naturally inclined toward critical thinking and that students ‘ critical thinking can be improved through guided instruction (Van Gelder, 2005) as cited in McGuire (2010). The study of McGuire focused on improving critical thinking through direct instruction in rhetorical analysis which held no improvement in pre- and post-intervention.

TABLE 3. Pretest and posttest level in science process skills of experimental and control group

Group	n	SD	Mean	Description
Pre-Test				
Inquiry-Based Approach	38	2.52	6.89	Developing
Inquiry-Based Approach Enhanced With Physics Olympics	38	2.34	7.61	Developing
Post-Test				
Inquiry-Based Approach	38	2.59	13.42	Approaching Proficiency
Inquiry-Based Approach Enhanced With Physics Olympics	38	3.25	16.84	Proficient

Legend: 36.00-45.00-Advanced (A);27.00-35.99-Proficient(P);18.00-26.99-Approaching Proficiency (AP);9.00 - 17.99 - Developing (D);0.00 - 8. 99 Beginning (B)

The mean scores of students in terms of their science process skills were developing level before intervention had been made (inquiry-based approach *M = 6.89, SD = 2.52;* inquiry-based approach enhanced with Physics Olympics *M = 7.61, SD = 2.34).* This developing level indicates that students possess the minimum knowledge and skills but need help throughout the performance of authentic tasks (K to 12 Curriculum Guide, 2013). This indicates that students both in the control and experimental groups already manifested both basic and integrated science process skills although in the developing level only. The results of standard deviation showed that the spread of scores of both groups are nearly the same which means that the two groups are homogeneous with regards to their pre-test science process skills. Table 3 also shows the levels of students' basic and integrated science process skills after they were exposed to the inquiry-based approach and both the inquiry-based approach and Physics Olympics. The result showed an increase in the mean score of students after exposure to inquiry-based approach and inquiry-based approach enhanced with Physics Olympics. The science process skills of students who were exposed to inquiry-based approaches advanced to Approaching Proficiency. This describes that students in this group have developed the fundamental knowledge skills and core understandings and, with little guidance from the teacher and/or assistance from peers, can transfer these understandings through authentic performance tasks. However, students exposed to inquiry-based physics Olympics advanced their science process skills to a Proficient level. This indicates that students in this group have developed the fundamental knowledge skills and core understandings, and can transfer them independently through authentic performance tasks. These imply that students' exposure to inquiry-based approach and inquiry-based Physics Olympics allowed the students to be efficient in applying techniques and giving importance to games increasing students' science process skills. This conforms to the findings of Turpin & Cage (2004) as cited in Ergul (2011) that hands-on activities incorporating inquiry-based science teaching to science instruction will improve science process skills.

Table 4. Gain scores in physics performance of experimental and control group

Group	Mean Score Before Intervention	Mean Score After Intervention	Mean Gain Score
Inquiry-Based Approach	15.79	32.92	17.13
Inquiry-Based Approach Enhanced with Physics Olympics	16.79	33.95	17.16

The result showed that students exposed to inquiry-based approach enhanced with Physics Olympics had a greater mean score in the pre and post-intervention as compared to the students exposed to inquiry-based approach. This tells us that students exposed to Physics Olympics activities gained more knowledge and understanding in Physics specifically in the topics (a) Motion in One Dimension (b) Waves (c) Sound as compared to students who were exposed to inquiry-based activities. This agrees with the results in a study found by Hickey, et al (2009) that students obtained larger gains in understanding and achievement while using the game.

Table 5. Gain scores in critical thinking skills of experimental and control group

Group	Mean Score Before Intervention	Mean Score After Intervention	Mean Gain Score
Inquiry-Based Approach	21.53	25.95	4.42
Inquiry-Based Approach Enhanced with Physics Olympics	21.55	26.42	4.87

Table 5 shows that students exposed to an inquiry-based approach enhanced with Physics Olympics (M=4.87) obtained a greater mean gain score compared to those students who were exposed to an inquiry-based approach (M=4.42). This tells us that the through Physics Olympics, students in the experimental group have improved their critical thinking skills. This conforms to the findings of Burbach, Matkin, and Fritz (2004) supported by Nelson and Crow (2014) that active learning strategies such as games did improve critical thinking skills.

Table 6. Gain scores in science process skills of experimental and control group

Group	Mean Score Before Intervention	Mean Score After Intervention	Mean Gain Score
Inquiry-Based Approach	6.89	13.42	6.53
Inquiry-Based Approach Enhanced with Physics Olympics	7.61	15.50	7.89

Table 6 revealed that students exposed to the inquiry-based approach and physics Olympics (*M*=7.89) obtained greater mean gain scores in science process skills compared to those students exposed to the inquiry-based approach (*M*=6.53). This is attributed to the fact that the Physics Olympics is highly interactive and allows the development of science process skills better than the inquiry-based approach. The result conforms to the statement as cited in Villanueva (2016) that hands-on manipulative experiences in science provide the key to the relationship between process skills in science.

Table 7. Differences in the pretest mean scores in physics performance, critical thinking and science process skills between the experimental and control groups

Variables	Group	n	Mean	df	t-value	Significance
Physics Performance						
	Inquiry-Based Approach	38	15.79	74	1.053	0.296
	Inquiry-Based Approach Enhanced with Physics Olympics	38	16.79			
Critical Thinking Skills						
	Inquiry-Based Approach	38	21.53	74	0.024	0.981
	Inquiry-Based Approach Enhanced with Physics Olympics	38	21.55			
Science Process Skills						
	Inquiry-Based Approach	38	6.89	74	1.272	0.207
	Inquiry-Based Approach Enhanced with Physics Olympics	38	7.61			

The *t-test* results revealed no significant differences in the pre-intervention Physics performance t (74) = 1.053, p = 0.296, critical thinking t (74) = 0.024, p = 0.981 and science process skills t (74) = 1.272, p = 0.207 of the students exposed to inquiry-based approach and those who were exposed both in inquiry-based approach and Physics Olympics. Moreover, results showed that the level of the students in terms of Physics performance, critical thinking, and science process skills in the two treatments were statistically similar and comparable. This indicates that the performances were comparable and both groups have the same level of prior knowledge and skills in physics which is developing. The present findings conform to the result of the study conducted by Mifsud, Vella, and Camilleri (2013) in which no significant differences in mean scores were obtained for the pre-test. This implies that both groups started with a similar level of ability. In addition, students in both groups are approaching proficiency in terms of inferring, recognizing assumptions, reasoning deductively, and interpreting and evaluating arguments based on the given propositions, passages, statements, or conclusions. This is in agreement with the findings of Hwang and Chang (2011) in Duran and Dokme (2016) "Inquiry-based learning is an instructive approach in which students can acquire information and improve their critical thinking skills using discovery and investigation in authentic settings". Lastly, the science process skills of students in both groups were not significant. This indicates that students in both groups were comparable in their science process skills before intervention. This result is supported by the findings of Osman and Vebrianto (2013) who explained that the mean scores for the science process skills test before intervention has been carried out are similar. There is no significant difference in the ability of the groups.

Table 8. Differences in the pretest-posttest mean scores in physics performance, critical thinking and science process skills of the control group

Test	n	Mean	df	t-value	Significance	Effect Size	95 %Confidence Interval	
Physics Performance							*Lower*	*Upper*
Pre-test	38	15.79	37	-13.853*	0.000	19.247	-19.637	-14.625
Post-test	38	32.92						
Critical Thinking Skills								
Pre-test	38	21.53	37	-5.688*	0.000	1.596	-5.996	2.840
Post-test	38	25.94						
Science Process Skills								
Pre-test	38	6.89	37	-10.863*	0.000	93.286	- 7.744	- 5.309
Post-test	38	13.42						

*$p < 0.001$

The *t-test* results revealed significant differences in the pre-test and post-test mean scores in physics performance t (37) = -13.853, p = 0.000, critical thinking skills t (37) = -5.688, p = 0.000, and science process skills t (37) = -10.863, p = 0.000, of the students exposed to inquiry-based approach The computed p-value in the physics performance was lower than the set alpha of 0.05 under a two-tailed test. Results showed that there was an increase in the mean score in physics performance from the pre-test to the post-test and was statistically significant. This describes that the students exposed to an inquiry-based approach gained more knowledge and understanding about grade 7 physics specifically on topics about (a) Motion in one Dimension (b) Waves and (c) Sound. This agrees with the study of Agustin (2018) that a significant difference existed in the performance of the students exposed to either game-based learning or inquiry-based instruction. Results further showed that there was an increase in the mean score in critical thinking skills from the pre-test to the post-test and was statistically significant. This result set forth that there was a change in students' ability to infer, recognize assumptions, reason deductively, and interpret and evaluate arguments in passages. In addition, the findings of the current study show that the inquiry-based approach makes positive contributions to students' critical thinking levels, concerns with the findings of other studies Mecit (2006), Wu and Hsieh (2006), McDonald (2004)as cited in Duran and Dokme (2016). Results also showed that there was an increase in the mean score in science process skills from pre-test to post-test and was statistically significant. This implies that there is an improvement in the basic and integrated science process skills of students. This result is supported by the findings of Villanueva (2016) who explained that science process skills facilitate learning in the physical sciences, ensure active students' participation, have students develop the sense of undertaking responsibility in their learning, increase the permanence of learning, and also have students acquire research ways and methods, that is, they can think and behave like scientists. It was further stated that science process skills are the building blocks of critical thinking and inquiry in science. Aside from the content presented in science curricula, science educators should be aware that teaching concepts and theories are more encompassing if learners are taught to apply what they have learned from classrooms to their daily lives. This would be possible if learners had mastery of science process skills to bridge concepts and theories to daily life applications. This result is in agreement with Leisen (2006) who claimed that the formation of the basic science process skills should be one of the objectives science teachers should have, especially those teaching Physics. Knowing these skills is the first prerequisite for science teachers to look for opportunities in compliance with the curriculum to build the skills of the students.

Table 9. Differences in the pretest-posttest mean scores in physics performance, critical thinking and science process skills of the experimental group

Test	n	Mean	df	t-value	Significance	Effect Size	95 %Confidence Interval	
Physics Performance							*Lower*	*Upper*
Pre-test	38	16.79	37	-18.673*	0.000	12.711	-19.012	-15.296
Post-test	38	33.95						
Critical Thinking Skills								
Pre-test	38	21.55	37	-6.792*	0.000	10.587	-6.321	-3.416
Post-test	38	26.94						
Science Process Skills								
Pre-test	38	7.61	37	-12.233*	0.000	8.670	-9.202	- 6.587
Post-test	38	16.84						

*$p < 0.001$

The *t*-test results revealed a significant difference in the pre-test and post-test mean scores in the Physics performance of the students exposed to an inquiry-based approach and physics Olympics t (37) = -18.673, p = 0.000. The computed *p-value* was lower than the set alpha of .05 under a two-tailed test. Results showed that there was an increase in the mean score in the physics performance from the pre-test to the post-test and were statistically significant. This agrees with the study of Agustin (2018) which showed that there was a significant difference existed in the performance of the students after they were exposed to either game-based learning or inquiry-based instruction. Another research finding done by Tolentino and Roleda (2017) supports this finding that there is a significant increase in student achievement when they are made to learn the subject in a gamified environment. Thus, a researcher should advocate the use of gamification in learning Physics. Table 9 also shows a significant difference in the pre-test and post-test mean scores in critical thinking of students who were exposed to inquiry-based approach and physics Olympics. The *t-test* results revealed a significant difference in the pre-test and post-test mean scores in critical thinking of the students exposed to inquiry-based approach and physics Olympics $t(37) = -6.792$, $p=0.000$. The computed *p-value* was lower than the set alpha of .05 under a two-tailed test. Results showed that there was an increase in the mean score in critical thinking skills from pre-test to post-test and was statistically significant. The result implies that the student's ability to infer, recognize assumptions, reason deductively, and interpret and evaluate arguments in passages had improved. The result of the present study conformed to the findings of Cetinbas-Gazeteci (2014) which states that science education supported by game activities had a significant positive effect on students' academic achievement and critical thinking abilities as cited in Duran and Dokme (2016). Moreover, the table also shows that there was an increase in the mean score in science process skills from the pre-test to the post-test, and was statistically significant t (37) = -12.233, p =0.000). This result is supported by the findings of Guevarra (2015) who emphasized that students demonstrated statistically significant gains in science process skills when exposed to innovative teaching approaches.

Table 10. Difference in the mean gain scores in physics performance, critical thinking and science process skills between the experimental and control groups

Variables Group	n	Mean	df	t-value	Significance	Effect Size	95 %Confidence Interval Lower	Upper
Physics Performance							*Lower*	*Upper*
Inquiry-Based Approach	38	17.13						
			74	- 0.139	0.890	0.153	-3.044	3.096
Inquiry-Based Approach Enhanced with Physics Olympics	38	17.34						
Critical Thinking Skills								
Inquiry-Based Approach	38	4.42						
			74	0.423	0.673	1.158	-1.659	2.554
Inquiry-Based Approach Enhanced with Physics Olympics	38	4.87						
Science Process Skills								

Inquiry-Based Approach	38	5.47	74	5.355*	0.000	15.708	2.363	5.163
Inquiry-Based Approach Enhanced with Physics Olympics	38	9.24						

*$p < 0.001$

Table 10 above presents the difference between the mean gain scores in physics performance of students exposed to the inquiry-based approach and those who were exposed to both the inquiry-based approach and physics Olympics. The *t-test* results revealed no significant difference after the intervention in Physics Performance of students exposed to the inquiry-based approach and those who were exposed to both in inquiry-based approach and Physics Olympics *t* (74) =-0.139, *p* = 0.890. Results showed that the mean gain scores of students in terms of Physics performance in two treatments were statistically similar and therefore were comparable and both groups may have gained the same amount of knowledge on the topic in (a) Motion in one Dimension and (b) Waves (c) Sound. It can be inferred from the findings of this study that either inquiry-based or Physics Olympics is effective in learning Physics. These two methods are both designed to make learners explore and do things on their own; and offer learners the opportunity to actively engage in the class activities. The result was similar to the findings of Agustin (2018) that students exposed to game-based learning have the same mean gain performance as the students exposed to inquiry-based instruction. These two methods of instruction are highly effective and notable strategies that can help students learn and understand Physics concepts (Dewey on Learning by Doing, 1963; Ang, 2012). Table 10 also presents the differences between the mean gain scores in critical thinking skills of students who were exposed to sole inquiry-based approach and those who were exposed to both inquiry-based approach and Physics Olympics. The *t-test* results revealed no significant difference in the mean score of critical thinking skills of the students exposed to the inquiry-based approach and those who were exposed to the inquiry-based approach with Physics Olympics *t*(74) = 0.423, *p* = 0.673 after the intervention. Results showed that the mean gain score of the students in terms of critical thinking skills in the two treatments was statistically similar and therefore were comparable. The *t-test* results revealed a significant difference in the mean score of science process skills of the students exposed to the inquiry-based approach and those who were exposed to the inquiry-based approach enhanced with Physics Olympics *t*(74) = 5.355, *p* = 0.000 after the intervention. Results showed that the mean gain score of the students in terms of science process skills in the two treatments was statistically different and therefore were not comparable. The slight difference in the mean gain of the two groups wherein the experimental group has a higher mean (*M* = 9.24) than the control group (*M* = 5.47) can be attributed to students' exposure to the different activities in Physics Olympics. Research supports the effectiveness of game-based learning in virtual environments. According to a meta-analysis of flight simulator training effectiveness, simulators combined with aircraft training consistently produced training improvements compared to aircraft-only training. In contrast, traditional, passive training approaches drill students into certain narrow procedures, and then evaluate them on their memory of what they were told. Even when they successfully retain the lesson's facts and procedures, their behavior in true-to-life situations remains untested. In addition, even the most comprehensive training program cannot cover procedures for every complex eventuality that they will encounter—no matter how thick the binder is. In game-based environments, students learn not only the facts but also the important, underlying how's and why's. This understanding of deeper, more abstract principles prepares them to perform consistently and effectively, even in new and unexpected situations. Bayir and Evmez (2019) found out that students develop better science process skills through playing science games.

CONCLUSION/IMPLICATION OF THE STUDY

The scores of the students in the pre-test Physics performance and pre-test science process skills test showed that students may have very little prior knowledge on the topic so the students required inputs from teachers or facilitators in order for them to master the desired learning competencies.

In terms of their critical thinking skills, students may have developed the fundamental knowledge and skills and with inputs from teachers and peers, he/she may be able to transfer these understandings into authentic performance tasks. These imply that the Physics Olympics helped improve the Physics performance, critical thinking skills science process skills of Grade 7 students. In addition, teaching using an inquiry-based approach and both inquiry-based and physics Olympics improves the mean gain performance and critical thinking skills of the students. This implies that either of the two methods when utilized in teaching will have a positive effect on students' performance and critical thinking. Lastly, the Inquiry-based physics Olympics when conducted properly affect significantly the mean gain score in science process skills arousing the interest of the students and motivating them to learn. The present findings on the effects of inquiry-based and physics Olympics on the performance, critical thinking, and science process skills of students have led to certain implications for theory and practice.

For Theory. The findings of this study revealed that the performance, critical thinking, and science process skills of students improved significantly after they were exposed to inquiry-based and inquiry-based Physics Olympics. The difference in the mean gain of those exposed to the inquiry-based with Physics Olympics did not vary significantly with those exposed to an inquiry-based approach which implies that either of the two methods will improve students' performance and critical thinking skills. However, the mean gain of both groups varies significantly in terms of their science process skills. The use of these methods in teaching agrees with the Social Constructivism theory of knowledge by Lev Vygotsky (1978) that applies the general philosophical constructivism to social settings, wherein groups construct knowledge from one another, collaboratively creating a small culture of shared artifacts with shared meanings (Palinscar, 1998). In addition, it is notable that game-based learning could arouse students' interest in discovering a concept, develop their sense of sportsmanship, and help them understand Physics easily as revealed in the qualitative results of the study. This supports the Game-Based Theory which allows the creation of a world for learners where they are free to analyze, plan, and experience things without any difficulty.

For Practice. The present investigation on the effects of inquiry-based approach and inquiry-based enhanced with Physics Olympics has brought certain implications for practice. The results of this study prove that inquiry-based alone and inquiry-based with physics Olympics are both effective in improving students' performance and critical thinking skills. Thus, teachers may employ either an inquiry-based approach or an inquiry-based with the physics Olympics in teaching Physics. However, inquiry-based Physics Olympics affect significantly the science process skills of students. Thus, to develop students' process skills in science, teachers are encouraged to use inquiry-based Physics Olympics in teaching Physics. Considering the learners as unique individuals, Physics Olympics games can be used in teaching to get students interested in the lesson, develop a sense of sportsmanship, and help to learn Physics easily. As revealed in the overall result of this study, the Physics Olympics affects not only the students academically but also a person as an individual. Therefore, teaching Physics in secondary schools should be incorporated with Physics Olympics to ensure effective and quality educational outputs. Moreover, with the fact that 21st-century learners are diverse learners, there is a need for teachers to utilize different approaches in the teaching-learning process to motivate students and develop their interests that would help them learn Physics effectively. The gamification of Physics classes enables maximum student participation and permanence of learning among them. This enables them to think critically while enjoying the activities as well. This would enable Physics classes to become more conducive to learning. Moreover, the gamification of Physics classrooms would pave the way for localizing and contextualizing classroom instructions. This would allow opportunities for science teachers to become innovative and creative in the delivery of their lessons. With this, it is suggested to adopt such pedagogy not only in Physics classes but across other science disciplines as well.

RECOMMENDATION

The Department of Education (DepEd) officials and Policymakers could make use of the findings of this study in designing, revisiting, or drafting a policy or a curriculum that will help address the needs of the current educational system, especially in the field of science, mathematics, and technology. In addition, they may also utilize the researcher-made physics Olympics as the basis for teachers' classroom enhancement activity. Likewise, the outcomes of this study will provide information and guidance to policymakers and curriculum developers on how the Physics Olympics games may be effectively incorporated into the curriculum. In this way, active student involvement will be ensured.

Textbook writers especially in Physics may use Physics Olympics games and varied laboratory activities as the basis for drafting or writing textbooks, learners' modules, and other instructional aids. Moreover, the result of this study will provide insights and information on how to write a textbook which will surely become useful and timely for the 21st century learners. Through this, they would likely contribute more to achieving the missions and visions of education. Since inquiry-based Physics Olympics have positive effects on the performance, critical thinking, and science process skills of students, school administrators may use the findings of this study as a means of improving students' performance, critical thinking, and science process skills. This may be used as a basis in designing curriculum, especially in science, math, and technology subjects to ensure students' active involvement in the process. Since games arouse the interest of students and motivate them to learn, teachers may use inquiry-based and physics Olympics activities in classroom instruction to help students with difficulties in Physics.

Students in other grade levels may also be exposed to Physics Olympics/game-based activities. Parents may know the potential of their children towards games. They may provide their children the moral support the latter need. With the care and moral support from parents, children would be motivated to do better in school and would not hesitate to try hard in their science class. The findings in the study may give the researcher insights into the importance of game-based learning to maximize class interaction and may also open other useful teaching-learning strategies that will address students' needs and interests. Moreover, the results of the study may also furnish the researcher with information about the weaknesses and strengths of the students; thereby, appropriate teaching strategies may be administered to remediate those. Future researchers may conduct similar studies using inquiry-based and physics Olympics in other grade levels. Furthermore, the same study may also be conducted in various schools to further prove its effect. They may also opt to investigate the qualitative aspects of this study such as the influence of inquiry-based Physics Olympics on students' behavior and the level of satisfaction in learning.

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