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Hands-on Structured Inquiry Activities in Physics: It's Effect into Students' Conceptual Understanding

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Abstract— This study determined the effect of hands-on structured inquiry activities in Grade 9 Mechanics on students' conceptual understanding. Specifically, it pursued to determine the performance of the students on the Grade 9 Mechanics pre-test, design hands-on structured inquiry activities in accordance with the low performed K to 12 Grade 9 science learning competency and determine the effects of hands-on structured inquiry activities on students conceptual understanding. Quantitative data were gathered using pre-test and post-test results of the researcher-made conceptual test. Qualitative data were gathered from designed hands-on structured inquiry activities and in the students' journal. The results showed that the Grade 9 students are in the beginning level in the entire learning competencies of Grade 9 Mechanics. Hands-on structured inquiry activities entitled "Water-Rocket Launching" for the competency on Describing the horizontal and vertical motions of a projectile, "How far will it go?" for Relating impulse and momentum to collision of objects, and "Safety First!" for Examining effects and predict causes of collision-related damages or injuries were designed. Students' conceptual understanding significantly improved from "beginning" to "developing" in the implementation of hands-on structured inquiry activities therefore, the designed activities can be adopted and utilized.

Index Terms— Conceptual understanding, Hands-on activities, Inquiry, Mechanics, Science curriculum, Structured-inquiry, Physics

1 INTRODUCTION

The transition of schools in the Philippines from basic-education curriculum to K-12 curriculum pushed schools to become competency-based and standard-based, offering great demands from the teachers who must be abreast with the set competencies. And so, to equate the demanding curriculum, teachers must provide innovative and meaningful approaches in teaching given that the thrust of Science Education in the country is to create scientific literacy among learners. Achieving this goal starts inside the classroom, where teaching – learning process is evidently present. In the current 4th industrial revolution where scientific information increases day by day, science education plays a key role in our societies.

The improved Philippine science curriculum will prepare learners to be informed and to be participative citizens capable of making judgments and decisions regarding applications of scientific knowledge. Further, the K to 12-science curriculum aims to provide learners with a repertoire of competencies important in the world of work and in a knowledge-based society. These competencies can also be attained by exposing the students in inquiry activities that will aid students' learning. Science activities that only require the students to read and think may not be applicable to today's generation. In opposition, activity-based type of learning boosts the development of students' brain by helping them to understand concepts and broadening their understanding of things. There were a number of these activities in classroom but few are hands-on which allows actual manipulation of environmentally seen materials. This in line with the statement of Ewers (2001) that doing science rather than simply reading and hearing it engages the students to test and build their own understanding. Further, it facilitates a better understanding of the subject by encouraging the students to complete the tasks. In addition, according to the U.S. National Science Education Standards (1996), when students are in the minds-on and hands-on activities, learners are learning by doing while thinking about what is being done.

Despite all the efforts done to improve instruction in previous years, national achievement test is still low in science over the years which exhibits alarming percentages like; 47.40% in SY 2008-2009, then a slight decrease in SY 2009-2019 with only 46.38%. Moreover, the most noticeable poor passing percentage in Science is the NAT result of SY 2011-2012 for High Schools, where the passing percentage in Science is 40.53% far from the goal of having a passing rate of 75%. In addition, there is also a decline in the enrolments in science and science related courses. The poor performance in science, especially in physics as one of the components of science subject, may be due to a number of fundamental reasons which could be due to shortage of science teachers in quality and quantity, inadequate laboratory equipment and facilities, and shortage of suitable physics textbooks (Akanbi, 2003), and these concerns are observably present in our country (Orleans, 2007).

An intervention like hands-on activities can engage students in actual manipulation of materials (Bruck and Towns, 2009; Haury and Rillero, 1994) which may be readily available in the learners' environment. Anchoring these activities to structured inquiry may further provide opportunities for students to apply and develop critical thinking because they will be given a scaffold to discover relationships between variables or generalize from data collected, which in essence caused them to learn better the process of science (Spears, 1997) – thus may result to better understanding physics concepts. In the context of foregoing discussions, the researcher deemed it significant to conduct the study on hands-on structured inquiry activities to examine its effect to students' conceptual understanding.

This study determined the effects of hands-on structured inquiry activities in Grade 9 Mechanics on students' conceptual

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understanding. Specifically, it sought to determine the performance of the students in the Grade 9 Mechanics, identify hands-on structured inquiry activities that may be designed in accordance with the low performed K to 12 Grade 9 science learning competencies, and determine the effect of hands-on structured inquiry activities on students' conceptual understanding.

2 Methodology

This study used descriptive research using pre-experimental design. Quantitative data were gathered using pre- test and post- test results of the researcher-made conceptual test. Qualitative data were gathered from the hands-on structured inquiry activities and on the students' journal. The researcher constructed 20 items test on Mechanics anchored on the learning competency of the Grade 9 Science. The test underwent evaluation of 3 physics teachers and pilot testing before it was utilized by the respondents. Also, the insights of the students regarding the hands-on activities were written in a journal. The effectiveness of the hands-on structured inquiry activities to students' conceptual understanding was measured using mean, performance level, change in the pre-test and post-test results and paired t-test.

3 Results and Discussion

Students Performance on the Pre-Test in Grade 9 Mechanics. The Department of Education envisions students who are competent in the field of Science. To see the performance of students specifically their level of competence, and to identify the least learned competencies, the researcher developed a conceptual test aligned to the learning competency of Grade 9 Mechanics.

Table 1. Students Performance in the Pre-test

Learning competency	No. of items	Mean	PL (%)	Interpretation
Describe the horizontal and vertical motions of a projectile	6	2.13	52	Beginning
Relate impulse and momentum to collision of objects	7	3.17	57	Beginning
Examine effects and predict causes of collision-related damages/injuries	7	3.83	67	Beginning
Total	***20***	***9.13***	***58.67***	***Beginning***

Table 1 shows the learning competencies where the students performed low in Grade 9 Mechanics. On "Describe the horizontal and vertical motions of a projectile", students have a performance level of 52%; "Relating impulse and momentum to collision of objects (e.g., vehicular collision)" with a performance level of 57% and "Examine effects and predict causes of collision-related damages/injuries" with a performance level of 67%. The performances in all of the learning competencies were interpreted as "Beginning" which supports the statement of Aina and Akintunde, 2013 that Physics is a subject student usually performed poorly in all level of the educational system. This means that the students are the struggling with their understanding and do not have enough knowledge of the competencies in Grade 9 mechanics. This suggests that the learners need further exposure to the "whats" and "hows" of the competencies and introducing activities that can be of help.

According to Pica (1997), to truly educate the whole child, teachers must address the needs of the mind and spirit in terms of the social or emotional, creative, and cognitive domains for lessons in physics that needs time to be absorbed and understood. Also, as emphasized by sociocultural theory of Lev Vygotsky (1978), students must be provided with enough support in the initial stages of learning new things to attain certain competence.

Designed Hands-on Structured Inquiry Activities in Accordance with the Low Performed K to 12 Learning Competencies in Grade 9 Mechanics. The goal of the present science education reform is to develop students who are critical in thinking, reasoning and acquire problem-solving skills. This requires instruction that allows students to think, reflect, judge, reason out, and prove scientific knowledge and claims. Using hands-on activities anchored on inquiry can enhance students' conceptual understanding.

According to Banchi and Bell (2008), most students need extensive practice to develop their inquiry abilities and understanding to a point where they can conduct their own investigation from start to finish. In this study, the researcher designed three activities to address the problem on the low performed learning competencies in Grade 9 Mechanics shown in table 2.

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Table 2: Designed Activities in Accordance to K to 12 Science Learning Competencies

Learning Competency	Activity title	Objectives	Material	Procedures
Describe the horizontal and vertical motions of a projectile	Water-Rocket Launching	A. Understand the concept of projectile motion in performing water-rocket launching; and B. Determine the horizontal and vertical components of the water rocket.	1.5- or 2-liters soft drink bottle (Water rocket) Launcher Pump Meter stick Protractor	1. Set up the launcher to a flat ground. 2. Put water on the soft drink bottle (2/3 of the bottle size). 3. Connect the bicycle pump (with pressure gauge) to the rocket launcher. 4. Put the rocket to the launcher with stopper vertically upright (90^0). 5. Start pumping to increase the pressure up to 4 kg/cm^3 (Bar) 6. Release the rocket. 7. Record the displacement of the water rocket from the launcher. 8. Repeat instructions #2 to #7 but on #4 the angle taken by the water rocket will be 70^0, 40^0, and 0^0 respectively.
Relate impulse and momentum to collision of objects (e.g., vehicular collision)	How far will it go?	A. Understand the relationship of momentum to the impulse; and B. Calculate problem involving impulse and momentum.	Stop watch weighing scale ruler basket ball Football Volley ball Lawn tennis ball	1. Measure the mass of basketball, football, volleyball, and lawn tennis ball. 2. Using stopwatch, measure the time taken by the balls situated 2 meters from the bottom of a plane inclined at 5^0 from the ground until it reach the lowest part of the inclined plane. 3. Put the basketball and football oppositely but on the same distance on top of the inclined plane. 4. Release the two balls at the same time. 5. Measure the displacement of the ball after collision and fill in the table with the unknown quantities 6. Repeat the process using volleyball and Lawn tennis ball.
Examine effects and predict causes of collision-related damages/injuries	Safety First!	A. Understand collision through observing the egg as it fall; B. Discuss the effect of collision to the egg on parachute.	balloon eggs rubber bond sewing thread paper cups clips	1. Set-up 1: Drop an egg from a height of 5 meters above the ground. Measure the time it take to reach the ground. Observe the egg as it drops. 2. Using balloon, rubber, sewing thread and paper cups, design and create a parachute that can carry an egg. 3. Set-up 2: Drop the parachute with an egg on its cup from the same height of 5 meters above the ground. Measure the time it takes to reach the ground. Observe the egg as it drops. 4. Compare your observations of the two set up.

In the first activity entitled “Water-Rocket Launching”, the students (1) understand the concept of projectile motion using performing water rocket; and (2) determine the horizontal and vertical motion of the water rocket. The second activity is entitled “How far will it go” has three objectives namely: (1) understand the relationship of momentum to the impulse; and (2) calculate problems involving impulse and momentum. The activity 3: “Safety First” aimed to understand collision through observing the egg as it falls and discuss the effect of collision to the egg with a parachute. In total, there were 3 activities designed to enhance students’ conceptual understanding in Grade 9 Mechanics. ment. According to Basagre (2018), teacher must guide the students to design logical procedures of their activities and arrived at the right interpretation of the result. This also adheres to the statement of Banchi and Bell (2008) Bransford, Brown and Cocking (2000) recognised the importance of allowing the students to perform authentic activities to have the opportunity to “learn their way around discipline by engaging in authentic intellectual task and opportunity for genuine knowledge creation”.

Effect of Hands – on Structured Inquiry Activities on stu dents Conceptual Understanding. Conceptual understanding can be defined as a deeper view on an idea or a concept by knowing what is behind it (Arons, 1997). In this study, this refers to the ability of the students to understand the Physics concepts which was determined based on the gained result of the post-test over pre-test of the respondents on the teacher-made test on mechanics. Their performance was determined using the 20-item conceptual test which is in line with the Grade 9 Mechanics learning competency. Table 3 shows the comparison of the pre-test and post-test result.

Table 3: Comparison of the Pre-test and Post-test Performance in the Conceptual Test

Learning competency	No. of item	Pre-test			Post-test		
		Mean	*PL*	*Interpretation*	*Mean*	*PL*	*Interpretation*
Describe the horizontal and vertical motions of a projectile	6	2.13	52	Beginning	3.6	75	Developing
Relate impulse and momentum to collision of objects (e.g., vehicular collision)	7	3.17	57	Beginning	5.6	83	Approaching Proficiency
Examine effects and predict causes of collision-related damages/injuries	7	3.83	67	Beginning	5.7	77	Developing
Total	***20***	***9.13***	***58.7***	***Beginning***	***14.9***	***78.3***	***Developing***

In the post-test result, the competency on describing the horizontal and vertical motions of a projectile reached 75% performance level which is interpreted as a “developing”. The learning competency on relating impulse and momentum to collision of objects has 83% performance level in the post-test which is interpreted as an “approaching developing”. Lastly, the learning competency on examining effects and predicts causes of collision-related damages/injuries have 77% performance level which is interpreted as “developing”. The overall post-test result got an average of 78.3% which is interpreted as “developing” level. The improvement can be associated with the implementation of hands-on structured inquiry activities anchored learning competencies wherein according to Holstermann (2009), hands-on activities can influence students’ interest differently. When students are exposed to hands-on structured inquiry activities, they tend to grasp the concept better. They are actively involved in the creation of knowledge as they do hands-on minds-on activities.

To determine if the effect of the employed intervention was significant on students’ conceptual understanding, paired t-test was used.

Table 4: Test of Significance

Computed t-value	Tabular t-value	Interpretation
10.73	2.045	*Reject null hypothesis*

For conceptual understanding, the test has df= 29, alpha value of 0.05, computed t-value of 10.73. The tabular t-value is computed is 2. 045 which is lower than the critical value, therefore, the researcher rejects the null hypothesis. This suggests that the difference between the results of the pre-test and post-test was significant. The Journal entry of the students reveals that they find it useful to use the structured hands-on inquiry activities to help them improve their prior knowledge. They also find it cool and enjoyable because according to them they have experienced the actual learning activities with their classmate. Letting them experience the activities helped them promote deeper understanding on the concept of the lesson. According to Richardson (1994), learning opportunities that provide a chance to "do" or experience the educational input, result in higher learning gains and retention.

4 Conclusion

In conclusion, the Grade 9 students were in the “beginning” level in the entire learning competency in Grade 9 Mechanics in their pre-test. Hands-on structured inquiry activities entitled “Water-Rocket Launching” for the competency of Describing the horizontal and vertical motions of a projectile, “How far will it go?” for Relating impulse and momentum to collision of objects, and “Safety First” for Examine effects and predict causes of collision-related damages or injuries were designed to address the low performed learning competencies in grade 9 mechanics and students’ conceptual understanding significantly improved using hands-on structured inquiry activities as intervention. These hands-on structured inquiry activities should be utilized and adopted by physics teachers especially for grade 9 mechanics to significantly improve students’ conceptual understanding. However, science teachers should identify other learning competencies in other areas of science that the students performed low in, use and develop more hands-on structured inquiry activities in mechanics and conduct similar studies using controlled and experimental groups modifying the number of items of the conceptual understanding test.

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