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Educational Outcomes from Learning Physics Through Guided Inquiry

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Abstract

This descriptive research, which employed quantitative and qualitative methods, aimed to determine the educational outcomes of guided inquiry lessons in Physics in terms of the following: improvement of students' inquiry skills, enhancement in scientific attitude, and the ability of students to connect the concepts to real-life experiences. Likewise, it described the students' meaningful learning experiences during the conduct of the lessons. The outcomes were anchored from the Science Education Framework of Philippines basic education. The participants in the study, students (N=728) and teachers (N=18), came from selected schools of the Department of Education Albay Division. Using thematic analysis, three themes related to meaningful learning experiences came from students' responses: understanding of concepts, participation in collaborative works, and opportunity for skills development. Results of t-tests for inquiry skills and scientific attitudes revealed significant improvements, with large effects. It was also found out that the students were able to connect concepts to their real-life activities.

Keywords: *guided-inquiry, Inquiry-based learning, inquiry skills, meaningful learning, real-life connection, scientific attitude*

Introduction

The Sustainable Development Goal (SDG) 4 - Quality Education is comprised of target outcomes as the backbone for the global campaign for education. One of these target outcomes is the development of relevant skills through learning opportunities. Among the skills enumerated are the high-level cognitive and non-cognitive/transferable skills (Hak, *et al.*, 2016; McKeown, 2002). In this regard, engaging learners towards the development of such skills should be a focus of educators. This is also one of the significant aims of science education today.

The Philippine science education has undergone reforms when the enhanced basic curriculum was implemented. Aside from its shift to spiral progression, the science education framework emphasizes the importance of interconnectedness among the three components: inquiry skills, scientific attitudes, and content and connections. These are deemed necessary to develop a scientifically literate learner who can apply concepts to real-life activities to make sense of the world (Kachergis *et al.*, 2017) and possesses values and attitude of science, especially when good dispositions are required (SEI-DOST, UP-NISMED, 2011).

From this structure, teachers are called to develop instructional materials with learning activities aligned to the attainment of the goal. The use of the inquiry-based approach in the teaching-learning process is one of the four approaches iterated as a major teaching approach in Philippine science education. It provides an opportunity for the learners to develop inquiry skills that include raising questions, planning investigations, gathering evidence by observing and using sources, analyzing, interpreting, explaining, communicating, reflecting and arguing, and evaluating (Harlen, 2014). Students perform activities that let them describe objects and events, ask questions, construct and test explanations, and communicate their ideas to others. Likewise, they use critical and logical thinking and consider alternative explanations to actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills (National Research Council, 2000; Duschl *et al.*, 2007). Science classrooms must allow the learners to develop these inquiry skills since these are essential in facing real-life situations (Windale, 2017).

Using inquiry, like the guided inquiry, in the teaching-learning process has yielded positive outcomes for the learners. Guided-inquiry is a type of inquiry that is learner-centered and involves the learners in finding and using various sources of information, motivating them to formulate questions, explore, and build new ideas guided by the teacher. Students who excelled in science revealed that science teachers engaging them in tasks involving investigation greatly inspired them (DOST-SEI, UP-NISMED, 2011). Moreover, being known as a model that organizes learners into a phenomenon, teachers believe inquiry also boosts learner's psychomotor and affective perspectives aside from the cognitive and improved learning process and outcomes (Af'idayanii , 2018).

There are already investigations conducted relevant to the outcomes or results of using the inquiry-based approach in science education, such as on students' achievement, science process skills (Lati *et al.*, 2012), and integration with other teaching and learning strategies. However, few focused on finding outcomes (Pedaste *et al.*, 2015) on student's inquiry skills and their ability to connect science concepts to real-life activities.

This study was intended to determine the educational outcomes from using the guided inquiry lessons in learning Physics, specifically, in terms of the students' improvement of inquiry skills and scientific attitudes and their ability to connect science concepts to real life. In this study, educational outcome referred to something that happens as a result of an activity or process. Likewise, it aimed to describe the students' meaningful learning experiences resulting from the conduct of the lessons.

This research was anchored on the theory of constructivism wherein learners interact with sensory data, construct their understanding and knowledge of the world (Steffe & Gale, 1995), and reconcile conflicts of ideas by performing activities. Hein (1991) pointed out that one's understanding is shaped not only through adaptive encounters with the physical world but through interactions between people in relation to the world. Here, the subject content, the learner's context, activities, and goals are considered as key ingredients of an effective learning outcome (Savery & Duffy, 1995). An inquiry-based classroom manifests the above situations wherein students learn through series of guided discussions, hands-on activities, and sharing of ideas.

Embedding learning in realistic and relevant contexts creates meaningful learning (Honebein, 1996, Ausebel *et al.*, 1978) because students can relate and transfer what they learn in school to everyday life. This is the pedagogical role of constructivism that becomes possible when students are allowed to make choices, such as choosing materials needed for constructing their knowledge of the phenomena, like in an inquiry-based classroom.

Since knowledge evolves through social interactions, collaboration is viewed to provide rich opportunities for understanding given phenomena (Glasersfeld, 1998). In addition, when mutual inquiry is practiced in the classroom (Lebow, 1995), collaborative partnerships like student-student, student-teacher, and student-experts, replace the traditional learning framework (Doll, 1989; Detel, 2015). Students develop their abilities by interacting with other students, adults, and the physical world.

This study also found relevance in Kolb's experiential learning theory, from which inquiry-based learning is grounded. It views learning to be effective when the learner executes all the four stages of the learning cycle, namely; encountering a new situation or interpreting existing experience; reflecting on the new or existing experience; concluding from experience; applying what was learned (McLeod, 2017). This is synchronized with inquiry-learning; the learner, as the center of the educative process, is involved in concept acquisition by transforming experience that he can apply to new situations.

A change in attitude towards agreeing to something is a manifestation of positive behavior. Olufemi (2012) claimed that attitudes tend to influence people throughout life. This study, likewise, found bearing to the mere exposure theory, which suggests that mere exposure to a stimulus is a sufficient condition for the enhancement of an individual's attitude towards it (Zajonc, 1968). The intervention given to the students for a specific duration has exposed them to the activities involving the processes of inquiry so that favorable changes in their scientific attitude occur.

Materials and Methods

Conceptual Framework

The Philippine K to 12 science education is learner-centered, inquiry-based, and aims to develop scientifically literate learners capable of making informed decisions regarding the applications of knowledge (Department of Education, 2013). This research utilized the developed and validated guided inquiry lessons in Grade 9 Physics as intervention materials to enhance student's learning in this area of science. The materials possess the following

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features: 7Es learning model, collaborative learning, and contextual (figure 1).

The guided inquiry lessons were held to contribute to the student's attainment of meaningful learning experiences in several aspects. Likewise, the student's improvement of inquiry skills, ability to connect the concept to real-life experiences, and enhancement of scientific attitudes form part of the materials' outcomes.

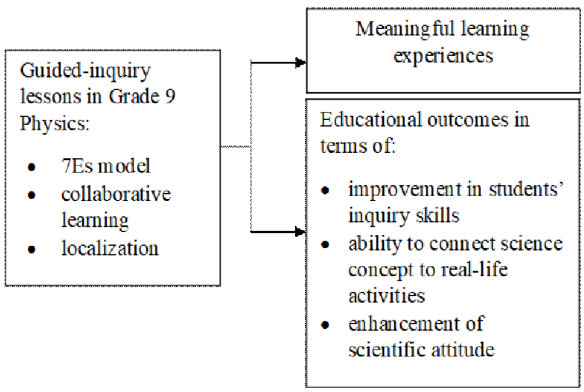

Figure 1. Conceptual Paradigm

Research Design

This study employed the descriptive research design using quantitative and qualitative methods. It described the meaningful learning experiences of the students and educational outcomes derived from the conduct of the guided inquiry lessons in Physics. The quantitative procedure was utilized to quantify the improvements in students' inquiry skills and scientific attitudes taken from the pretest and posttest results. The qualitative method was used to analyze data coming from the students' journals.

Participants

The study was conducted in nine randomly selected schools in the Department of Education (DepEd), Albay Division. These schools were headed by a Principal I or a Head Teacher and considered as small schools based on categorization according to the school population. Being a small school also has fewer science teachers. Likewise, because of the limited slots given per school during the four consecutive years of mass training for the K to 12 Science curricula for junior high school, not all science teachers could attend. The said training involved a walkthrough on the content of science and teaching pedagogies that included the use of inquiry-based approach from which the lessons used in this study were patterned.

A total of 728 Grade 9 Junior High School students enrolled for the school year 2017-2018 participated in the study (table 1). Eighteen teachers served as observers.

Instruments

Ten guided-Inquiry based lessons for Grade 9 Physics were used as alternative materials in teaching the subject for one quarter of the school year. The lessons are the following: Projectile Motion, Momentum and Impulse, Momentum and Impulse: Effects and Causes, Work, Power, and Energy: Energy Transformation, Conservation of Energy, Conservation of Energy: Total Mechanical Energy, Heat, Work, and Energy, Heat, Work, and Energy: Heat Transfer and Energy Transformations; Electrical Energy Generation, Electrical Energy Transmission and Distribution. These lessons were the products of collaborative activities with the teachers coming from the participating schools.

The learning competencies included in the lessons were the following: investigate the relationship between the angle of release and the height and range of the projectile, relate impulse and momentum to the collision of objects (e.g. vehicular collision), examine effects and predict causes of collision-related damages/ injuries, explain energy transformation in various activities/events, perform activities to demonstrate the conservation of mechanical energy, infer that the total mechanical energy remains the same during any process, explain why machines are never 100 % efficient; explain how heat transfer and energy transformations make heat engines like geothermal plants works, and, explain how electrical energy is generated, transmitted and distributed. Moreover, these developed lessons utilized the 7Es model of elicit, engage, explore, explain, elaborate, evaluate and extend phases.

In the elicit phase, the teacher extracted prior understanding of the students about the concept from which new knowledge was built through questions and scenarios. The activities in the engage phase included capturing students' attention by providing engaging short activities or events associated with daily activities to help them focus on the content, and the conversation was provided for all. In the explore phase, the students were given the opportunities to show scientist-like attitudes such as thinking, planning, investigating, and organizing collected information through activities done by the

Table 1. Participating Public Secondary Schools in the Division of Albay

Schools	District	Participants	
		Students	Teachers
San Francisco National High School	Malilipot	33	2
San Fernando National High School	Sto. Domingo	56	2
Joroan High School	Tiwi	95	2
Pariaan National High School	Camalig North	62	2
Cawayan High School	Manito	65	2
Lower Binogsan High School	Guinobatan West	87	2
Jovellar National High School	Jovellar	200	2
Marigondon National High School	Pioduran	85	2
Matacon National High School	Polangui South	45	2
Total		728	18

group. During the explain phase, students working in groups were tasked to analyze what they have found out, clarify their understanding from short reflective activities, and explain what they have done. In the elaborate phase, the teacher facilitated the transfer of learning from one concept to another, giving importance to applying concepts to new contexts or real-life activities. Test items aligned to the learning objectives were provided in the evaluate phase. In the extend phase, the students were given tasks regarding applying the concepts learned to the new context.

Other features of the lessons included collaborative learning, where the students worked in groups on collaborative activities and localization by incorporating community resources in the lessons. The materials were subjected to experts' evaluation and underwent several revisions before the implementation.

After every lesson, a student journal guide was provided to the students. Insights gained from the lesson, meaningful learning experiences acquired during the lesson, and how the lesson was related to real-life were sought from students after each lesson.

To measure the improvement in students' inquiry skills, the inquiry skills test (Cronbach=0.81), was administered before and after the conduct of the lessons. This was composed of eight open-ended questions prepared based on the learning competencies and patterned after the Trends in International Mathematics and Science Study (TIMSS, 2015) items. The inquiry skills for Grade 9 level were adopted from the Science Framework for Philippine Basic Education (DOST-SEI, UPNISMED, 2011). A rubric was used to score the answers.

A five-point scale scientific attitude questionnaire, with a reliability of 0.71, was used to determine the students' scientific attitude. It was composed of nine elements of the scientific attitude adopted from the Science Framework for Philippine Basic Education (DOST-SEI, UP-NISMED, 2011). This questionnaire was administered before and after the implementation of the lessons. All instruments were validated by jurors.

Data Analysis

T-test was used to determine whether there is a significant difference between the pretest and posttest scores for the students' inquiry skills and scientific attitudes. The effect size was determined to find out the quantity of change in the students' mean scores.

The thematic analysis (Clark & Braun, 2014) was employed to identify themes from the students' written responses. An inductive analysis of data involving the iterative reading of the responses was done until codes were formed that were then developed into themes. Revisions of the coding framework were done based on the suggestions of two researchers who have been doing similar analyses. Informed consent was sought. A focus group discussion with selected students was conducted to validate the themes and supplement quantitative data.

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Results and Discussion

Meaningful learning experiences are described as worthwhile events (Kostiainen *et al.*, 2017), activities, and circumstances that students personally value (Okukawa, 2008). Three themes were developed and associated with the students' meaningful learning experiences due to the guided inquiry lessons. These themes were: understanding of concepts, participating in collaborative activities, and opportunity for skills development, were formed from the seven (7) codes (table 2).

The student's understanding of concepts was manifested in two situations: discovering the meaning of concepts and situations by making reflections and applying the concepts in real-life activities. The sample extracts along these codes show that students understand the physics concepts by reflecting (Costa & Kallick, 2008) and associating them with their recent experiences. Likewise, they show meaningful learning in terms of finding applications of physics concepts to their real-life activities. The first theme is supported by Novak's (2002) statement describing meaningful learning in terms of cognitive development and situating the knowledge learned into a relevant cognitive structure.

Participating in collaborative activities is another theme developed from three (3) codes: student-to-student, student-to-teacher, and student-to-family members. Collaboration in a classroom is a process giving students opportunities to interact (Thomson *et al.*, 2009) or work together to achieve a common goal, which usually is an improved learning outcome. It can be noted from the extracts that working together enabled the students to learn new ideas, made their tasks lighter, and cultivated friendship. Vygotsky (1997) sees learning taking place when students interact with their peers, teachers, and other experts. Engaging learners in collaborative processes give great significance to their learning experience (Okukawa, 2008).

The third theme is the opportunity for skills development derived from two (2) codes: manipulative skills and presentation skills. The extracts along the first code demonstrate an exercise of psychomotor skills (Kempa,1986) showing students' ability to handle objects with control in the context of scientific investigation. Activities engaging students to handle tools are considered as a feature of science that can boost interest (Allen, 2012) towards meaningful learning. Possessing a good technique (Fadzil & Saat, 2017) in manipulating scientific tools helps minimize acquiring experimental errors. Meanwhile, the sample extracts along the second code indicate that students take responsibility for preparing and delivering a presentation. Comments coming from the students in the audience can provide valuable reflection, making the presentation a meaningful learning situation (Borisova *et al.*, 2019).

Table 2 shows that students find learning of science to be meaningful when they can understand the concepts presented, participate in collaborative works, and be given the opportunity to enhance their skills. This statement finds support from Ausubel and colleagues (1968) and Jonassen and Strobel (2006), stating that meaningful learning happens when there is an acquisition of new understandings, which are interactional products of a learning process. For lessons to be meaningful, they should be designed so that students may become interested and involved in the learning process (Wlodkowski & Ginsberg, 2010).

Improvement in the student's inquiry skills

The results from the t-test indicate a significant difference ($p=0.05$), between the mean score of the pretest and posttest for each inquiry skill. Having a very large effect size (Ferguson, 2009) also indicates that the guided inquiry lessons helped improved the students' inquiry skills.

The results shown in Table 3 mean that the students manifested improvement in their ability to formulate questions beyond direct observations and based on scientific principles. They can organize and evaluate data based on evidence and other relevant information from reliable sources. Likewise, their answers to questions are always linked to scientific content knowledge, with reasonable and logical arguments, and presented with an appropriate or alternative perspective.

The result further indicates that learning Physics through guided inquiry improves the inquiry skills of the students. This outcome is in accordance with Mulyana and colleagues (2018) in finding significant results on student learning outcomes through the guided inquiry model since it targets skills and cognitive development (Ekici & Erdem, 2020).

Moreover, the results in Table 3 are also supported by teachers' observations on the students' behaviors while doing guided inquiry tasks. They observed that their students would re-read and tried to understand the objectives of the activity, ask questions, and discuss expectations among themselves. They brainstormed and sketched observation procedures. Some members

Table 2. Themes on students' meaningful learning experiences that emerged from the codes

Themes	Codes/frequency	Sample extracts
Understanding of concepts	discovering the meaning of concepts and situations by making reflections (418)	*"The diagram presented by the last group made me understand better how electric energy is generated in a geothermal power plant. My group lacked enough explanation to understand the functions of the motor in electric energy generation. Next time, we must find more references that will support our ideas."*
		"From the simple activity on the effects of collision, I became aware of its impact, especially on vehicular accidents. I needed to take precautionary measures when riding on a motorcycle from home to school and vice versa."
		"After reflecting on our teacher's comment regarding our diagram on electric energy transmission and distribution, I better understood how electric energy is distributed to the consumers in my place. I also understood the reasons behind the rotational brown-outs that we frequently experience."
	applying concepts to real life activities (644)	*"...that is why I see the connection of projectile motion in catching fish. In order for my hook to reach a maximum range, I throw it at a particular angle while slightly bending my body sidewards."*
		"I also understand the reason why, as much as possible, we iron clothes once a week." "This lesson also confirms our practice of switching off lights when not used."
		"I now understand the functions of large pipes I see every time I pass near the geothermal plant area."
participation in collaborative works	student-student collaboration (667)	*"Mostly, we collaborate with group mates in performing experiments. I learned how to listen to group members, and how to discuss and present ideas to them."*
		"Being the group leader, I learned how to delegate tasks to members based on their capabilities. I saw this as a good technique to finish the tasks easily and on time."
		"Working with members is also an opportunity to learning new things because, in our group, we discuss concepts and find solutions to problems."
	student-teacher collaboration (335)	*"During the design process of our simple turbine model, we were able to identify the appropriate materials based from the explanations of our teacher. We sometimes worked with our teacher to check if we are doing it correctly. Working with our teacher boosted our confidence and self-esteem."*
	student-expert collaboration (143)	*"I sought the help of my older sister, a science teacher, in explaining energy transformation, then I was able to answer all questions in our homework."*
		"My father, who is an electrician, explained to me how electricity is transmitted and distributed. I requested him to give comment to my constructed diagram and improved it based from his suggestions."

would already predict the result of the activity once a relationship among variables is recognized. There were instances when some groups lack tools for the activity so that they would improvise using available materials they find in their surroundings, considering, however, this limitation as a possible source of error in their results. The group activities were presented to the class using manila paper or, in some instances, via an LCD projector. They always included illustrations and graphs, whichever was appropriate, in their presentations. A notable comment from the teacher-observer was that some students struggled to do inquiry tasks and finish them on time at the start of the implementation of the lesson. However, as the lessons progressed, they became used to the tasks and performed them applying the procedures of inquiry learning.

These observations are manifestations of outcomes achieved through guided inquiry learning (Andrini, 2016). On the whole, the guided inquiry lessons helped learners improved their inquiry skills.

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Table 2 (continuation). Themes on students' meaningful learning experiences that emerged from the codes

Themes	Codes/frequency	Sample extracts
opportunity for skills development	manipulative skills (411)	*"For example, I used a ruler and cutter, in cutting plastic strips as blades in our simple turbine. In order not to make mess, I practiced first handling the glue gun before attaching the strips around the plastic ring. It was the first time I handled such tool but after several trials, I finally discovered the technique."*
		"Throwing a stone to get the maximum range was challenging because I had to undergo several trials to come up with a satisfying result."
	presentation skills (531)	*"We used a simple flow chart as an aid in presenting our understanding on how electricity reaches our houses from the generation plant. There is an explanation written below every box in the flow chart. We assigned a group member to present the output."*
		"We used a graph in presenting our data on the efficiency of the given machines. We verified if all spelling of words and units of quantities were correct."
		"I rehearsed several times so that I may not be able to forget important things to be discussed in our presentation. During the practice, my groupmates recorded the time I spent in presenting our output orally. Because of that, I was able to completely present our report within the allotted time."

Table 3. Pretest-posttest mean scores of students (N=728) on inquiry skills test

Inquiry Skills Maximum Points	Mean±SD				
	Pretest	Posttest	t	p-value	d
Asking questions (6)	2.24±0.81	4.04± 1.22	46.61*	<0.000	1.7
Designing appropriate procedure, materials, tools, and equipment (6)	2.20±0.81	4.00±1.19	41.37*	<0.000	1.8
Employing different strategies to obtain information (6)	2.01±1.00	4.02±1.22	50.59*	<0.000	1.8
Communicating answers/ results using appropriate presentation strategy/tool (6)	1.98±1.27	4.19±1.31	50.49*	<0.000	1.7

**Significant at $p<0.05$*

Enhancement of student's scientific attitude as an outcome of guided inquiry

Table 4 shows that the students possessed acceptable scientific attitudes before the implementation of the guided inquiry lessons and were enhanced after the conduct of the lessons (Cohen's d = 1.37). This means that the guided inquiry lessons enabled the students to manifest good scientific attitudes.

The results of FGD on selected students revealed that they became more curious as the lessons progress. They would always desire to investigate through experiments and learn from their results. Most of them practiced creativity by designing procedures in inquiry activities and presenting the results of experiments. Along with intellectual honesty, the students remarked that they do not copy anymore from other's work. Instead, they gave a truthful report of their findings.

Moreover, they also tried their best to avoid experimental errors by using proper equipment. Every time they improvised tools, they would always test for the usability of their improvised devices through the trial-and-error method. The students claimed that they participated actively in a group discussion because they want to express their views. They also listened to others' explanations because they learned from them. Finally, they reported that they carried out the tasks assigned to them to the best of their abilities.

Table 4 also shows that learning through guided inquiry improves students' scientific attitudes. Widowati and colleagues (2017), using inquiry learning in his materials, also improved students' curiosity and other categories of scientific attitude. Learning through guided inquiry creates significant influence (Wildan *et al.*, 2019; Khusniati, 2012) on scientific attitude, an essential outcome in learning science, equally important as scientific knowledge (Gokul & Malliga, 2015). These imply that teachers can provide the students with learning experiences that are designed not only based on knowledge and skills acquisition but also on attitudes to be acquired.

Students' ability to connect science concepts to real life as outcome of guided inquiry lessons

Included in the guiding principles of the science framework for Philippine basic education is making science relevant and useful (DOST-SEI, UP_NISMED, 2011), connected to the real world. A real-world connection allows the students to see the reason for learning the lessons and doing the activities and assignments. Table 5 presents manifestations of how the students see connections of Physics concepts to real-life situations.

It can be seen from the table that the students were able to see connections of concepts to real-life. Competencies 1, 3, and 4 got the most number of applications cited by the students. These are applications related to sports, preservation of life, and activities consuming energy. The least numbers of connections given were for competencies 6, 7, and 8.

The FGD conducted with selected students revealed that they find it hard to think of other applications aside from what they already mentioned since their activities are only limited within their surroundings. Their activities outside the school were also limited. This implies that more examples can be presented in the lessons, or teachers can revisit the strategies employed in these lessons to address improvement in this outcome. As a whole, all students were able to see the connection of concepts to real life.

Implications and Limitations of the Study

Out of the 14 small schools from DepEd Albay Division that were randomly selected from where the participants should come from, 60% participated. Those schools that are located on islands and those far from the town proper were not able to participate. However, the sample size was sufficient for the study. A similar study can be conducted at each school that was not able to participate. This research can also be expanded to medium and large schools.

Another limitation was due to a natural calamity that occurred in the province during the implementation of the lessons. One school became an evacuation center, and another school had its entire population relocated to a nearby town. Although the students from these schools suffered inconveniences while attending their classes, all lessons were still implemented. Students who were not able to attend the class regularly were excluded from the study.

Conclusion

Learning outcomes are important to know if learning goals are achieved. This study concludes that improvement in the students' inquiry skills and scientific attitudes as outcomes of the guided inquiry lessons were attained. However, to achieve the maximum improvements, the lessons can be revised to include provisions to address the limitation along with lesson implementation. In addition, the guided inquiry lessons enabled the students to connect the concepts discussed to their real-life and acquired meaningful learning experiences.

Table 4. Data on students' scientific attitude before and after the implementation of the guided inquiry lessons (N=728)

	Mean±SD	Description	Mean Difference	t	p value	d
Pretest	3.37±0.69	Acceptable	0.82	2.21	0.000	1.37
Posttest	4.19±0.48	Good				

$p<0.05$; 1.00 – 1.80- very poor, 1.81 – 2.60- poor, 2.61 – 3.40- acceptable, 3.41 – 4.20- good, 4.21– 5.00- very good

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journal.bicol-u.edu.ph

Table 5. Students' responses on connecting concepts to real-life experiences. (N=728)

Lesson	Concepts and real-life connections	Frequency of mention
1. Projectile Motion	1.1 Shooting the ball in the ring in a form of parabola is an example of projectile motion.	603
	1.2 Hitting fruits in the tree can be done with great speed and good angle to be able to hit the fruit.	104
	1.3 An object can reach a long range if thrown at 45o.	512
	1.4 Throwing a fishing hook in the sea.	57
	1.5 Application of projectile in sports like "sipa", archery, soccer, diving, etc. and in fireworks	411
2. Momentum and Impulse	2.1 Heavy objects are difficult to stop	389
	2.2 Avoid running in school when the bell rings in order not to bump with other students to prevent accident.	12
	2.3 A large impulse means that a great force is experienced by the occupants of the cars in car crash.	319
	2.4 A car that has more momentum will cause more damage on the car that has lesser momentum	490
3. Momentum and Impulse: Effects and Causes	3.1 Fast moving cars have great momenta and damage will also be great if accidentally bumps moving or non-moving objects.	288
	3.2 A car with airbag can reduce injury since the driver or passenger is prevented to contact completely on the interior of a vehicle if he hits another car.	363
	3.3 Accident can be prevented by being careful.	77
	3.5 Wearing a helmet to protect the head of the motorcycle driver in case of accidents.	664
	3.6 Take necessary precautions when walking along the road.	155
4. Work, Power, and Energy: Energy Transformation	4.1 Flowing water in the river can be used to turn blades (kinetic energy to mechanical energy)	129
	4.2 Food we eat transforms to chemical energy to mechanical energy for us to do work	435
	4.3 In a battery is a chemical energy which can be transformed to electrical energy then to mechanical energy of mini fans.	569
	4.4 In riding a boat, the fuel (chemical energy) is transformed to kinetic energy so the boat pushed through the water.	29
	4.5 During "brown out" (power loss), the generator uses fuel, chemical energy is transformed to electrical energy then to light energy, or sound energy.	432
	4.6 The fire makes the water in the kettle boil (from chemical energy to heat energy).	109

Table 5 (continuation). Students' responses on connecting concepts to real-life experiences. (N=728)

Lesson	Concepts and real-life connections	Frequency of mention
5. Conservation of Energy	5.1 A spurting water directed towards the plastic blades can rotate the blades. Kinetic energy of the water is converted to mechanical energy. If the blades are in large scale and the amount of water is great, the blades can rotate the turbine of a generator to produce electricity.	594
	5.2 For example, when riding in a swing moving upward, the kinetic energy is converted to potential energy.	446
	5.3 Riding in a roller coaster during festivals, the potential energy is converted to kinetic energy, then to potential energy.	228
6. Conservation of Energy: Total Mechanical Energy	6.1 Example in the pendulum, the total mechanical energy is conserved at every point of its motion. The swing is similar to the pendulum's motion.	439
	6.2 In riding in a roller coaster, at the top it has a large potential energy, then when moving down, the potential energy is converted to kinetic energy. If no other force is exerted on the roller coaster, it goes up, having potential energy. If no other force acts on it to make it stop, then the total mechanical energy is conserved.	211
7. Heat, Work, and Energy: Efficiency of Machines	7.1 In lifting loads, some amount of work done by the machine is used to overcome friction	395
	7.3 Bicycle has many moving parts which contribute to more friction, making it to have lesser efficiency	319
8. Heat, Work, and Energy: Heat Transfer and Energy Transformations	8.1 In geothermal plant heat is transferred from the source (steam), then heat is converted into mechanical work.	203
	8.2 Thermal energy to mechanical energy to electric energy	115
9. Electrical Energy Generation	9.1 Steam is used by Tiwi geothermal plant to produce electricity. Then electricity is transmitted to electric distributors, like APEC, then distributed to houses, schools, hospitals, etc	497
	9.2 Frequent "browouts" experienced in the province is due to low amount of energy generated.	523
10. Electrical Energy Transmission and Distribution	10.1 Steam from the geothermal plant runs the turbines of the generator to produce electricity. The electricity is transmitted through electric tower grids and distributed to substations then to households.	519
	10.2 Electricity reaches houses through transmission lines.	312

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