Effect of Learning by Design Approach in Teaching Physics

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Abstract. This paper analyses the effect of the implementation of a STEM lesson plan utilizing Learning by Design approach in teaching Newton's Third Law of Motion. This study employed one group pretest-posttest research design. Pilot testing of the STEM Lesson was done to develop an enhance lesson activity. The enhance lesson activity was conducted to the 8th-grade students of a public school in one of the Junior High School in Iligan City using the PPITR (Present the scenario, Plan, Implement, Test and Revise) framework. The implementation of this lesson gives opportunity for the students to test and redesign their rocket output. Result shows that high, average, and low ability students benefited the learning by design approach.

1. Introduction

Education is the might in the development of any nation; it is a fact that the countries with an effective system of education lead the world, both socially and economically. However, we can't deny the fact that educational systems are not that firm. In effect, it causes problems and difficulties in teaching. In Science, for example, there are difficulties engaged by the students in understanding scientific concepts. Science educators in the 21st century are facing a myriad of issues, the availability of appropriate textbooks, classroom resources, the preparation and training of science teachers, the dramatically increasing use of the Internet as a source of information [1]. In harnessing of student focus [5], and lessons that hold students' interest [6] science instruction fails to engage students' interest and is divorced from their everyday experiences. Traditional science instruction has tended to exclude students who need to learn from context that is real world, graspable, and self-evidently meaningful, she added.

Students experience and apply the concepts they are learning. Too often, teachers see that students can mark answers on a test, but can't apply those same concepts outside of the classroom. Learning by Design not only teaches children how to use the concepts they are learning but why they would be useful in "the real world." In this way, this makes what the children are learning more meaningful and better retained. One of the biggest challenges science teachers now faces creating lessons that will not only get students to learn but also hold the interest of the students [1]. [8]. When students are interested in teaching and are doing hands-on activities, learning is evident. Hands-on learning gets students involved and is responsible for their knowledge [7].

It is along with the premise that this study is pursued. The researchers desire to use Learning by Design Approach in teaching Newton's 3rd Law of Motion. The primary purpose of this study is to implement learning by design approach in teaching Newton's 3rd Law of Motion. Specifically, the study sought to answer the following question:
1. Identify the process of implementation of learning by design lesson.
2. Compare the conceptual understanding of the students based on their ability.

2. Methodology
The researchers used the one group pretest-posttest design. Qualitative data were drawn from the implementation of the designed lesson plan. Quantitative data were obtained from the respondent's scores in the achievement test and the evaluation of their output. Respondents of the study were the 45 Grade 8 students from a public school in one of the cities in Mindanao, Philippines. Participant parents allowed their son/daughter to participate in the study. The lesson was implemented for five meetings.

3. Research Findings
Students were tasked to design a paper rocket and discuss the science concept in their design. Figure 1 shows the process of implementing the Learning by Design Approach (LBD).

1. First Step is to present the scenario; students were given the opportunity to respond to a problem situation on designing a rocket
2. Second Step is to Plan that includes the necessary measure to solve the problem on rocket design
3. The Third Step is Implement in which students execute their plan.
4. Fourth Step is Test; the students try out their rocket
5. Final Step is Revise if the outcome is successful or not, students will have the opportunity to make changes to their initial rocket design.

The process of implementing the learning by design approach gives opportunity for the students to work in pairs in planning their rocket design and redesign based on their evaluating. The Test and Revise stage allows students to be more creative in designing their rocket.

3.1. Conceptual Understanding
Students were asked about their conceptual understanding regarding the activity. The following are the questions used to measure their conceptual understanding:

| Question | Response |
|----------|----------|
| 1. Why does the rocket fly? | “Because of the baking soda and vinegar.” (G1) “Because of the chemical vinegar and baking soda that can make the rocket fly.” (G2) “Because there is the pilot inside the rocket ship.” (G3) “The rocket flies because of the chemical reaction between the vinegar and the baking soda that is the cause the rocket fly.” (G4) “By the reaction of the vinegar to the baking soda.” (G5) |
Four out of five groups answered that the reason why the rocket flew was the chemical reaction that occurred between the baking soda and vinegar. A simplified explanation of Newton's 3rd law of motion states that every action has an equal reaction.

2. How are the rockets being launched?

| Group | Description |
|-------|-------------|
| G1    | “Our rocket did not fly maybe because of the amount of baking soda and vinegar given to our group.” |
| G2    | “Our rocket sad to say are not launched (either) because of our baking soda and vinegar are fewer than the other groups are there launched are greater their vinegar and sod’s so that there rocket are launched in the highest.” |
| G3    | “The rocket launched by mixing the baking soda and vinegar correctly.” |
| G4    | “By adding some vinegar and some baking soda and then shake it.” |
| G5    | “By the reaction of the vinegar and baking soda.” |

Three out of five groups answered that mixing the vinegar and baking soda launches the rockets. Constructivist lessons provide students with experiences that often challenge their assumptions of the world.

3. What makes a good rocket design?

| Group | Description |
|-------|-------------|
| G1    | “The good rocket design is the upper rooftop side.” |
| G2    | “If the design is heavy and complete foundation.” |
| G3    | “By using the materials that make the rocket attract.” |
| G4    | “It makes the rocket balance and through this it can make the rocket heavy or light.” |
| G5    | “The good foundation.” |

Here we say that all of the groups considered that having a good foundation makes a good rocket design. Students who physically experience scientific concepts understand them more deeply and score better on science tests [4].

The qualitative result was also supported using the scores of the students on their rocket output. Table 1 shows the student's score and description of their output. The students’ output “rocket” was assessed using a score guide with descriptions. Result showed that there were four groups of students who have excellent outputs and one group who had good output. Creating a model is essential for student understanding [3] Students can visually see their solutions come to life and can redesign based on their evaluation of their output.
Table 1. Description of the “Rocket” Output

| Group Number | Score (50 pts.) | Level of Performance | Description |
|--------------|-----------------|----------------------|-------------|
| Group 1      | 36              | Fair                 | Body tube is straight, symmetrical, and is held together well. Fins are not attached straight and spaced evenly around the body. The nose cone fits well with the body of the rocket somehow attaches to the body tube in some way. |
| Group 2      | 37              | Satisfactory         | Body tube is straight, symmetrical, and is held together well. There are no fins attached around the body of the rocket. The nosecone perfectly fits to the body of the rocket and somehow attaches to the body tube in some way. |
| Group 3      | 38              | Satisfactory         | Body tube is straight, symmetrical, and is held together well. There is one missing fin on the other side of the rocket and does not attached. Nose cone fits well with the body of properly the rocket and somehow attaches to the body tube in some way. |
| Group 4      | 43              | Very Satisfactory    | Body tube is straight, symmetrical, and is held together well. Fins are perfectly attached to the body of the rocket. The nose cone perfectly fits to the body of the rocket and somehow attaches to the body tube in some way. |
| Group 5      | 33              | Fair                 | Body tube is straight, symmetrical, and is held together well. But there is missing fin on the other side of the rocket. The nosecone perfectly fits to the body of the rocket and somehow attaches to the body tube in some way. |

Comparison of Conceptual change among of the Low, Average and High ability students

The researchers grouped the students into low, average and high based from their previous science grades; 75-79 was grouped as "low", 80-85 was arranged as "average" and 86 above were grouped as "high" ability students. Figure 2 shows that there is an increase of their understanding about the said topic was observed. The result also confirms the findings of Aquino, Buan (2018); learning by design approach shows an increase in the conceptual understanding of the respondents [2]. After engaging in learning by design activity, which resulted in an enhanced students understanding of the topic they studied.
The researchers further analysed the gain scores of the students based on their ability. Analysis of variance was used to determine if there is a substantial difference in the gain scores of three groups. Based on the result found in Table 2, the students’ abilities has no significant effect on the gain scores at p>.05 [F (2,19) = .975 p=0.395]. Result implies that high, average, and low level of performance respondents benefited the learning by design approach. Students also expressed based on the focus group discussion, the lesson develops set of experiences for them to construct their meaning from things.

| Sum of Squares | Df | Mean Square | F     | Sig. |
|---------------|----|-------------|-------|------|
| Between Groups | 18.488 | 2 | 9.244 | .975 | .39 |
| Within Groups  | 180.103 | 19 | 9.479 |       |     |
| Total          | 198.591 | 21 |       |       |     |

4. Conclusions
Based on the outcomes of this study it was demonstrated that the Learning by Design approach was implemented using the PPITR (Present the problem, Plan, Implement, Test and Revise) in teaching Newton’s Third Law of Motion. The process of implementation allows learners to solve a problem and interact with peers in creating their rocket design. Based from the data gathered, there was an increase on the conceptual understanding of the students. Also there was no significant difference among low, average and high ability students. The students were able to made good rocket design and the students were also able to understand the concept behind the launching of the rocket as evident by the output that they have designed. Based on the findings of the study, the researchers recommends that science teachers may design tasks that promote student engagement through problem solving, decision-making and interaction with others.

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