(Hard Copy)
E-ISSN : 2456-1045

ARJMD

- International Journal
- Most Cited Journal
- Peer Review Journal
- Indexed Journal
- Open Access Journal
- University Recognized Journal

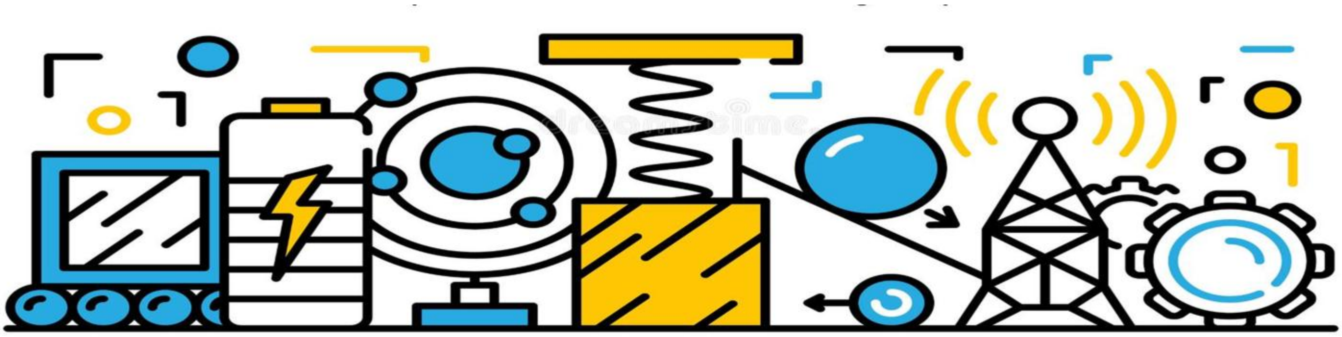
RESEARCH JOURNAL

VOLUME - 67 | ISSUE - 1

ADVANCE RESEARCH JOURNAL OF MULTIDISCIPLINARY DISCOVERIES

NOVEMBER 2021

INTERNATIONAL JOURNAL FOUNDATION
Specialized in academic publishings only
www.journalresearchijf.com



Design Thinking Approach in Teaching Physics

ORIGINAL RESEARCH ARTICLE

ISSN : 2456-1045 (Online)
ICV Impact Value: 72.30
GIF- Impact Factor: 5.188
IPI Impact Factor: 3.54
Publishing Copyright @ International Journal Foundation
Article Code: EDU-V67-I1-C1-NOV-2021
Category : EDUCATION
Volume : 67.0 (NOVEMBER-2021 EDITION)
Issue: 1(One)
Chapter : 1 (One)
Page : 01-09
Journal URL: www.journalresearchijf.com
Paper Received: 24th DECEMBER 2021
Paper Accepted: 2nd JANUARY 2022
Date of Publication: 20th JANUARY 2022
DOI: 10.5281/zenodo.5873526

NAME OF THE AUTHOR(s)

Nerrie E. Malaluan[1]
***Joy N. Landicho[2]**

College of Teacher Education,
Batangas State University,
Philippines

ABSTRACT

This study aimed to determine the effectiveness of design thinking approach in teaching physics to Grade 8 students of Padre Vicente Garcia Memorial Academy, Inc. during the school year 2018-2019. It determined the students' levels of performance in the pre-test and post-test in the experimental and control groups after which test results were compared. The development of students' skills along the phases of design thinking such as empathizing, ideating, prototyping, and testing was likewise part of the study. Moreover, the level of students' understanding and appreciation of the approach in learning physics concepts was determined. Research output as based from the findings was an instructional guide utilizing design thinking approach to enhance students' understanding about physics concepts. The findings revealed that levels of students' performance in the pre-test were comparable but differed in the post-test indicating that design thinking approach positively affected the students' performance. Generally, there was strong concurrence that the phases of design thinking approach developed varied skills among students. In addition, design thinking as an approach in learning physics was well-understood and appreciated. From the findings, an instructional guide utilizing design thinking approach integrating its phases was developed to serve as a tool in conducting interactive classes in physics that will engage students in design challenges. It was recommended that the proposed instructional guide be used to enhance the teaching of physics concepts to Grade 8 students. Also, educators may explore innovative strategies that would cater to the needs of 21st century learners.

KEYWORDS: academic performance, design thinking approach, experimental, innovation, physics learning.

CITATION OF THE ARTICLE

Malaluan N.E ; Landicho J.N. (2021) Design Thinking Approach in Teaching Physics; *Advance Research Journal of Multidisciplinary Discoveries;* 67(1) pp.01-09

** Corresponding Author*

I. INTRODUCTION

The need for innovation is greater now than before, especially in the field of education requiring use of innovative teaching strategies to develop the skills demanded by this century such as creativity, critical thinking, collaboration, and communication among learners. Empowering learners with 21st century skills is essential as they thrive in this modern world which requires indispensable critical thinkers, problem solvers, digitally literate, effective communicators and innovators. Shifting to a more innovative educational strategies could help the country produce learners who are equipped with 21st century skills. This perspective demands transformation in the way how learners should be educated.

Of the sciences, the subject physics, in particular, deals with a bulk of information needed to understand everyday occurrences. Since matter and energy are the basic constituents of the natural world, physics is vital in understanding the laws governing the nature and so the universe. Its goal is to show understanding on how the universe operates at its most basic level. More importantly, this subject concentrates in developing the theory and mathematics of different laws, focuses on the application of principles to practical problems and intersects with engineering. Certainly, physics being considered as the mother of all sciences requires broad technical background and set of problem solving skills that can be applied to various fields. Definitely, the subject needs strategies for it to be understood and be productive to students' lives.

Because of the abstract nature of physics, it is perceived as a difficult course. As evidence, students in physics have poor performance in national and international assessments. Esiobu [1] affirmed this by saying that physics is a key science subject that demands to be learned by the students to make meaningful understanding of the natural world. One of the factors that affect the poor academic achievement of students in physics is the strategy utilized by teacher in teaching the subject. Without the use of an effective strategy, learning physics concepts might not become successful. The teaching of physics without giving priority to teaching methods or strategy might result to poor academic achievement.

An environment where students take an active participation and engagement for the construction of knowledge is an avenue for the effective learning of physics concepts Buabeng, 2015 [2]. Thus, learners should be engaged to learn in way that they have ownership of their own learnings. Effective physics learning occurs when learners have direct participation in which they are responsible and take account on discoveries, exploration and interactive learning.

Teachers, including physics teachers need to develop a repertoire of teaching strategies owing to differences in students' needs and learning styles. Bodrova [3] stated that understanding physics concepts and principles is explained thoroughly upon experimental testing where the causes and effects of certain natural phenomena are studied activities such as scientific experiments and investigations may be provided in physics to make students engaged in the learning process. Working in a group enables students to learn effectively and so the better the chances of developing logical thinking skills. Actively engaging students in science helps them develop good attitudes and dispositions.

Albert Einstein once said that the only source of knowledge is experience. This implies that learning is best achieved when students are engaged in real-life scenarios which could make the retention of knowledge longer. This also applies to physics learning. As such, confining students to traditional methods of instruction may not lead them to the effective learning of physics lessons. Thus, teachers are challenged to consider innovative strategies to prepare the students by helping them to develop 21st century skills that are essential in this rapidly evolving world.

Central to this, science teachers should be able to design teaching sequences to develop students' creative and critical thinking abilities which are important to make their learning meaningful. It is expected from teachers to create a conducive learning environment where learners are allowed to interact meaningfully with each other so that they can acquire longer retention of learning's. In addition, the way teachers pose questions to students could also determine the level of interactions inside the classroom. Development of students' thinking skills and maintaining a learner-centered environment allow students to participate and collaboratively engage to learn scientific skills and processes.

Design thinking is an approach to learning that develops students' creativity. In design thinking, teachers and students are involved in design challenges that focus on understanding the problem through empathizing, generating ideas, building prototypes as a solution and testing to gather feedbacks and improve the design. For Ray [4], design thinking may develop and enhance the twenty-first century skills of learners as they work to identify and solve problems in an interactive manner. In solving problems, communication, collaboration, creativity, and critical thinking skills are highly considered to meet the design challenge. He suggests working in small groups and observing the following six steps: identify the problem; design a solution; make a prototype; test; get feedback; then present. One of the basic rules concerns the way of asking the questions and expressing the opinion. Students are encouraged to agree or disagree with other's ideas. This is done in order not to discourage other students from expressing their opinion and to search alternative ideas which is essential in building prototypes.

Design thinking involves collaboration to address the problem and give solution. It is a way of thinking where students gather ideas to construct meaningful solution and provide a better outcome. It means empathy as the focus is on user needs. At the same time, it is holistic because it looks at a wider context for the customer. As design thinking process is not linear but cyclical and each cycle is built upon the previous one, it is iterative. On top of that, the method encourages "outside the box thinking" to come to a creative and innovative outcome Baeck & Gremett [5].

Dam [6] describes design thinking as a solution-based approach, a methodology of solving problems. It is beneficial in solving complex problems by understanding the needs of users involved, by defining the problem, by generating and refining ideas to form solution, by engaging in a design challenge through prototyping and testing. Design thinking process involves understanding the problem by observing, empathizing and immersing with people to gain knowledge and develop a sense of empathy. If one can relate with the feelings of the persons involved, a deeper understanding is possible. As a result, relevant information will be generated leading to problem's solution.

As cited by Creighton [7], design thinking gives students the opportunity to learn by doing real-world projects that open to the development of their skills such as, critical thinking, creativity, collaboration and communication. Involving students in design thinking process makes them learn through a project-based approach. This process of learning helps them to become more active learners as they take part and become responsible of their own learning. The projects they make bring relevance to the lesson being studied, thus promoting longer retention of knowledge.

In response to the challenge of using innovative method in teaching, the researcher aims to promote the design thinking as a teaching method to enhance the 21st century skills of the students. The researcher believes that design thinking will develop the skills of the students along its four distinct phases. The researcher, being a science teacher has witnessed the need of physics lessons to be taught in a more engaging way so that learners will actively take part of the learning process. The Philippines lags behind among other nations in the world in terms of science education and it is the researcher's sincere desire to help and promote innovation.

II. OBJECTIVES

In this study, the effectiveness of design thinking approach was determined by comparing the level of performance of the students in the control and experimental groups. The development of students' skills along the phases of design thinking such as empathizing, ideating, prototyping, and testing was likewise part of the study. Student's understanding and appreciation of the approach were also determined. This study was concerned with the development of Physics instructional guide that may enhance the utilization of design thinking approach for the better acquisition of knowledge and better performance of the students.

III. MATERIALS AND METHODS

A. Research Design

The design of this study is a combination of descriptive and experimental designs. The descriptive design was used to assess the skills developed along the phases of design thinking as well as the level of students' understanding and appreciation of the approach. The experimental method was employed to determine the effectiveness of design thinking approach in teaching physics.

B. Participants

The participants of the study were 50 Grade 8 students of Padre Vicente Garcia Memorial Academy, Inc. during the school year 2018-2019. The researcher used two sections of Grade 8 students wherein each section was composed of 25 students for experimental group and 25 students for the control group. To establish comparability, grades in science in the previous year were considered. Moreover, the results of the pre-test and post-test were taken in consideration. The experimental group used the design thinking approach following empathizing-ideating-prototyping-testing process. However, the control group utilized the traditional method of teaching.

C. Instruments

There were two instruments used in this study namely: achievement test (pre-test and post-test) and the questionnaire. This test was designed by the researcher to assess the performance of the two groups before and after the teaching-learning process was conducted. The content of this instrument was submitted to experts for comments and suggestions. Their suggestions and comments served as basis for the improvement of the items before this was subjected to a pilot test for further refinement and for determination of the test reliability. After the test was validated, the 50-item test was pilot tested to 25 students who had finished Science 8.

The data that were gathered were subjected to item analysis. The indices of difficulty and discrimination were also computed for each item and the results were used for final version. Items with difficulty and discrimination indices within 0.21-0.80 were retained. Items were revised and improved based on the results of item analysis.

The final draft of the achievement test was retested to a group of 25 students on the same month. The results of the test were used to determine the coefficient of validity and reliability. The reliability of test was calculated using the Kuder-Richardson formula. A reliability coefficient of 0.8214 was obtained. The Pearson Product-Moment Coefficient of Correlation between the physics achievement scores and the final grades of this group of students were used to determine the validity of the test. The test registered a validity of 0.8463. After finding the validity and reliability of the test, it was administered to the control and experimental groups.

Table 1. Grade Range in Scoring of Achievement Test

Grade Range	Verbal Interpretation
90-100	Very High (VH)
80-89	High (H)
70-79	Average (A)
60-69	Below Average (BA)
50-59	Poor (P)

The researcher prepared a questionnaire administered to the experimental group to determine how design thinking approach develops students' skills along its phases, namely: empathizing, ideating, prototyping and testing. The second part of the questionnaire dealt with the level of understanding and appreciation of the students on design thinking approach in learning physics concepts. The instrument underwent the process of construction, validation, administration, and scoring.

D. Procedure

The researcher, through a letter of request asked permission from the office of the school principal of Padre Vicente Garcia Memorial Academy to conduct an experimental study in the school. Upon approval, arrangements with regard to the changes of schedule of the concerned teacher and students was made. Both groups were taught the same lessons but with different approaches. The study was conducted during the first grading period where physics was the focus in Grade 8.

Before the conduct of the study, the researcher explained to the experimental group the necessary procedures that entailed in using the new approach in teaching physics. Both the control and experimental groups were given pre-test before proceeding to the process. The researcher employed the design thinking approach as a teaching method in physics for the experimental group and the traditional approach for the control group. The physics lessons that were covered are: Newton's laws of motion, potential and kinetic energy, heat transfer and electricity.

After the last lesson, a post-test was administered to both groups to determine their post-test scores and so, the level of performance. The experimental group was given a questionnaire that was designed to assess the skills that may be developed by the design thinking approach along its phases. The questionnaire also assessed the level of students' understanding and appreciation on design thinking.

Table 2. Scale and Range Used to Describe Verbal Description

Option	Scale/Range	Verbal Interpretation
4	3.50 – 4.00	Strongly Agree/Very High
3	2.50 – 3.49	Agree/High
2	1.50 – 2.49	Disagree/Low
1	1.00 – 1.49	Strongly Disagree/Very Low

E. Data Analysis

The following statistical tools were used to quantify the data gathered in the study. Weighted mean was used to determine the assessment of students on how the design thinking approach may develop students' skills along its phases and determine the level of students' understanding and appreciation of the approach. Kuder Richardson Formula 21 was used to determine the reliability coefficient of the pre-test and post-test. Pearson Product Moment of Correlation was used to determine the reliability of each of the test items. T-test for dependent means was used to compare the pre-test and post-test results for each group and t-test for independent means was used to find out the level of performance of the experimental group and the control group.

IV. RESULTS AND DISCUSSION

As to the control group, it can be seen on the table that there were twenty students who got grades which ranged from 60-69 and belong to the below average performance. There are four students who had poor performance as indicated by their grades which ranged from 50-59 and one student who obtained an average performance as indicated by the grade which is in the range of 70-79. In the experimental group, there were twenty-two students who had below average performance as indicated by their grades which ranged from 60-69. Two students got grades ranging from 50-59 which indicate a poor performance and one student obtained an average performance as indicated by the grade which is in the range of 70-79.

Table 3. Difference on Pre-test Level of Performance of the Control and Experimental Groups

Level	Control	Experimental
Average (70-79)	1	1
Below Average (60-69)	20	22
Poor (50-59)	4	2
Total	**25**	**25**
Mean	**63.60**	**63.84**

Table 4. Difference on Post-test Level of Performance of the Control and Experimental Groups

Level	Control	Experimental
Very High (90-100)	0	8
High (80-89)	15	15
Average (70-79)	10	2
Total	**25**	**25**
Mean	**80.84**	**87.88**

On the other hand, table 4 presents the difference on post-test level of performance of the control and experimental groups. In the control group, there were fifteen students who got grades which ranged from 80-89 that indicate a high level of performance. There were ten students with an average performance as indicated by their grades which are in the range of 70-79. In the experimental group, there were also fifteen students who got grades ranging from 80-89 that indicate a high level of performance. There were eight students with a very high level of performance as indicated by their grades which ranged from 90-100 and two students with an average performance as indicated by their grades which are in the range of 70-79.

Table 5. Difference on the Performance of the Students in the Control and Experimental Groups

Variable	t_c	p - value	Decision on H_0	Interpretation
Pre-test	0.225	0.823	Do not Reject	Not Significant
Post-test	5.007	0.000	Reject	Significant

$\alpha = 0.05$

It can be noted from the table, that the computed t-value of 0.225 with a corresponding p-value of 0.823 which is greater than 0.05 level of significance, indicates that the null hypothesis should not be rejected. This finding revealed that the students in the control and experimental groups were both not able to answer correctly most of the test items in analyzation of the concepts relating to the application of laws of motion, conservation of potential and kinetic energy, heat transfer and electricity in real-life situations. The results of the pre-test indicates that the two groups had the same level of performance which is low.

Results also show that the obtained t-value of 5.007 with a corresponding p-value of 0.000 which is less than 0.05 level of significance suggests that the null hypothesis is rejected. This shows that the grades of the students in the experimental group were higher than those in the control group. This can be attributed to the design thinking approach used by the teacher in teaching the physics concepts.

As can be seen in table 6, students strongly agreed that verbal communication skill was developed in empathizing phase through talking to people to understand the problem scenario. This obtained the highest weighted mean of 3.72. This becomes evident when studying the concept of electricity. Using design thinking, they interviewed children who are the recipients of their cars to know what kind of car would make them happy. This supports the idea of Ineta [8] that design thinking provides untraditional and innovative tasks that develop students' problem solving skills by working in groups to solve the tasks that help in enhancing their collaboration and communication skills.

Likewise, the students strongly agreed that design thinking developed their social skills as they interacted with others and their listening skills by giving attention to the thoughts of others. These two items obtained a weighted mean of 3.68. It can be explained by their experience during the empathizing phase wherein the students were allowed to talk and interact with people to gain knowledge about the problem given to them. They were able to take note by listening to the people who are expert about the problem. This supports the concept from Stanford Education that during the empathizing phase, students talk to people or experts to gain understanding of the problem. The goal is to have background knowledge as a primary step in solving the problem.

Moreover, the students strongly agreed that design thinking developed their emotional awareness by sharing and understanding the feelings of others about the problem. This got a weighted mean of 3.60. During the design thinking processes, the students of the experimental group were exposed to problem scenarios so they were able to feel and understand the feelings of others about the problem. Just like in dealing with the concept of potential and kinetic energy. Some students are asked on what they feel when riding a roller coaster and what design do they enjoy the most. This can be attributed to the story of Chagala that in order to build a miniature bridge, his students read a story about a child who could not get across a river. Through this, the students had a deeper understanding of the problem by experiencing the feeling of the child who could not get across the river.

As a whole, the composite mean was 3.58 which indicates that the respondents strongly agreed in all items used to describe the students' skills developed by empathizing phase of design thinking approach such as verbal communication, social, listening, emotional awareness, observation, inquiry, and reflecting skills. This affirms the idea of [7] that learning through design thinking gives students the opportunity to develop key skills such as communication, problem solving, collaboration, and critical thinking.

Table 6. Development of Students' Skills along Empathizing

Items	WM	VI
1. Verbal communication skills by talking to people to understand the problem scenario	3.72	SA
2. Social skills by interacting with other people	3.68	SA
3. Listening skills by giving attention to the thoughts of other people	3.68	SA
4. Emotional awareness by sharing and understanding the feelings of others about the problem	3.60	SA
5. Observation skills by being mindful with the surroundings where the problem exists	3.56	SA
6. Inquiry skills by asking people using my own curiosity	3.56	SA
7. Inquiry skills by conducting research to gather data about the problem	3.40	A
8. Reflecting skills by processing the ideas gathered while listening to other people	3.40	A
Composite Mean	**3.58**	**SA**

Legend: *WM – Weighted Mean, VI – Verbal Interpretation, A – Agree, SA – Strongly Agree*

Table 7. Development of Students' Skills along Ideating

Items	WM	VI
1. Critical thinking skills by making decision out of the problem	3.68	SA
2. Critical thinking skills by solving the problem	3.64	SA
3. Verbal communication skills by sharing my ideas to my classmates without hesitation	3.60	SA
4. Social skills by respecting the ideas of my classmates while brainstorming on the possible solution	3.49	A
5. Reasoning skills by making sense of the ideas gathered	3.48	A
6. Critical thinking skills by analyzing the data gathered from empathizing	3.48	A
7. Innovative skills by thinking critically and creatively to design real world projects	3.48	A
8. Critical thinking skills by evaluating the people's perspectives about the problem	3.44	A
Composite Mean	**3.54**	**SA**

Legend: WM – Weighted Mean, VI – Verbal Interpretation, A – Agree, SA – Strongly Agree

In table 7, the students strongly agreed that ideating developed their critical thinking skills by solving the problem. This obtained a weighted mean of 3.54. During the lessons conducted, the students worked in group to think of the possible solutions to the problem. Critical thinking skill was developed during the ideating phase especially when the students are brainstorming about the possible solution to the problem. This supports the idea of [8] that in design thinking, students work in groups to solve the tasks and develop their critical thinking skills that will be useful in solving real-life problems in an innovative way.

Likewise, students strongly agreed that ideating developed their verbal communication skills by sharing ideas to their classmates without hesitation. This got a weighted mean of 3.60. In using design thinking approach, communication is always evident because the students work in group and in order to successfully do the challenge, they have to communicate effectively. This supports the ideas from Stanford Education that in ideating, students are challenged to brainstorm and generate ideas without hesitation. No one's ideas are rejected, instead they are encouraged to communicate with one another.

To sum it up, the composite mean of 3.54 indicates that the respondents strongly agreed in all items used to describe the students' skills developed by ideating phase of design thinking approach such as critical thinking, verbal communication, social, reasoning, and innovative skills. This supports the idea of [5] that design thinking is constructive thinking that encourages to come up with a creative and innovative outcome. It can also be gleaned on the idea of [7] that design thinking develops key skills such as critical thinking, communication, problem solving and creativity.

As can be gleaned in the table, the students strongly agreed that prototyping developed their creativity skills by making a model/design. This obtained the highest weighted mean of 3.80. Its high rank could be explained by the experience of the students to always come up with a prototype. They built a rocket, roller coaster, travel thermos and toy car. This conforms the story of Chagala that after conducting research and brainstorming ideas, the students build prototypes. Consequently, as cited by [7], learning through design thinking engages students in real-world projects which give the opportunity to develop key skills such as critical thinking, creativity, collaboration and communication. Involving students in design thinking process makes them learn through a project-based approach. The projects they make bring relevance to the lesson being studied, thus promoting longer retention of knowledge.

Moreover, the students strongly agreed that prototyping developed their patience by exerting efforts on achieving the output with respect to time. This obtained a weighted mean of 3.76. In every lesson conducted, the students were given limitations wherein time is one these limitations. They were able to work under time pressure but without neglecting the quality of their prototypes. This supports the idea that design thinking believes in the creativity of every individual no matter what the situation is. Whatever limitations exist around, designing can be an enjoyable process.

Likewise, students strongly agreed that their verbal communication skills is being developed in prototyping phase by sharing ideas while working on the prototype. This got a weighted mean of 3.68. While working on their prototypes, the students were able to add input on how their prototypes could be at its best. When they encountered lapses, they worked collaboratively to fix and improve their designs. This becomes evident when they are making their prototypes; rocket, roller coaster, travel thermos and toy car. This conforms to the idea of [4] that in design thinking, students are encouraged to express their opinion and search alternative ideas which are essential in building prototypes.

To sum up, the composite mean of 3.63 indicates that the respondents strongly agreed in all items used to describe the students' skills developed by prototyping phase of design thinking approach such as creativity, soft skills (patience and flexibility), verbal communication, time-management, innovativeness, resourcefulness, and collaboration skills. This supports the concept of [7] that collaboration is central to design thinking where students develop key skills such as communication, collaboration and creativity. As also noted by [8], design thinking welcomes innovation.

Table 8. Development of Students' Skills along Prototyping

Items	WM	VI
1. Creativity skills by making a model/design	3.80	SA
2. Soft skills (patience) by exerting efforts on achieving the output with respect to time	3.76	SA
3. Verbal communication skills by sharing ideas while working on the prototype	3.68	SA
4. Soft skills (flexibility) by engaging myself in different hands-on design challenges	3.60	SA
5. Time-management skills by working effectively with respect to the given time	3.60	SA
6. Innovative skills by thinking critically and creatively to make real-world projects under design challenges	3.60	SA
7. Resourcefulness by innovating materials to be used in the prototype	3.56	SA
8. Collaboration skills by working harmoniously to achieve the desired output	3.44	A
Composite Mean	3.63	SA

Legend: *WM – Weighted Mean, VI – Verbal Interpretation, A – Agree, SA – Strongly Agree*

The table below shows that the students strongly agreed that testing developed their emotional stability by accepting the failures on the design and remaining calm under stressful circumstances. This obtained the highest weighted mean of 3.88. This reflects the experience of the students that their prototypes do not work all the time. Sometimes, they experience to fail and have unexpected outcomes. On these instances, they are challenged to remain calm and innovate their designs. This can be associated with the idea that design thinking allows students to fail but gives them the opportunity to reiterate and improve their design for a better outcome. As mentioned by [8] students learn to make their own mistakes and realize that there are no right or wrong solutions to various problems. They learn to express their opinions and listen to the ideas of others.

Table 9. Development of Students' Skills along Testing

Items	WM	VI
1. Emotional stability by accepting the failures on the design and remaining calm under stressful circumstances	3.88	SA
2. Receptive skills by understanding and accepting feedbacks	3.72	SA
3. Creativity skills by thinking and reiterating the design	3.64	SA
4. Innovative skills by thinking critically and creatively to improve the prototype	3.64	SA
5. Collaboration skills by working together to address the lapses on the prototype if any	3.42	A
6. Behavioural skills (sportsmanship) by showing fairness during competitions under design challenges	3.40	A
7. Critical thinking skills by identifying what works and what did not on the design	3.36	A
8. Verbal communication skills by giving suggestions to improve the design	3.36	A
Composite Mean	**3.55**	**SA**

Legend: WM – Weighted Mean, VI – Verbal Interpretation, A – Agree, SA – Strongly Agree

Likewise, the students strongly agreed that testing developed their receptive skills by understanding and accepting feedbacks. This got a weighted mean of 3.72. During the testing phase, the students experienced to gather feedbacks regarding their prototypes. On this phase, the students understanding was tested on how they would accept the suggestions given to further improve their prototypes. This conforms to the idea of [8] that in design thinking, the students learn to explain their opinions and listen to other opinions, accept untraditional ideas thus welcoming innovation.

To sum up, the composite mean of 3.55 indicates that the respondents strongly agreed in all items used to describe the students' skills developed by testing phase of design thinking approach such as emotional stability, receptiveness, creativity, innovativeness, collaboration, behavioural, critical thinking, and collaboration skills. This affirms with the idea of [7] that design thinking gives the opportunity to develop critical thinking, creativity, problem solving, communication and collaboration.

It can be gleaned in the succeeding table that the students had very high understanding in design thinking that it demands students to make prototypes. This got the highest weighted mean of 3.80. This shows students were aware prototype is the main demand of the design thinking approach. Students experienced to create prototypes in every lesson presented. To understand the laws of motion, they built rockets. To explain the conservation of kinetic and potential energy, they built roller coasters. To deduce how heat transfers, they built travel thermos and to demonstrate a basic circuit, they built toy cars. This finding supports the idea of [7] that design thinking involves engaging students in a form of project-based learning where they use the mindset and methodology of design to find and solve problems.

On the other hand, students had high level of appreciation that design thinking engages students in hands-on design challenges, and allows students to determine early the weaknesses of the prototype and take actions immediately and engages students in real-world projects. In using design thinking approach, the students experienced to learn the laws of motion through rockets, conservation of mechanical energy through roller coasters, heat transfer through travel thermos and basic circuit through a toy car. Also, they were able to gather feedbacks and reiterate their prototypes when they met undesirable results. This conforms to the idea of [5] that one of the attributes of design thinking is constructiveness. It is a constructive thinking, a solution-based approach that search for a better solution to the problem.

Table 10. Level of Students' Understanding and Appreciation of the Approach in Learning Physics Concepts

Items	WM	VI
1. Demands students to make prototypes	3.80	VH
2. Has four phases, namely: empathizing, ideating, prototyping, and testing	3.72	VH
3. Develops metacognitive awareness	3.68	VH
4. Provides opportunities to work together for students' collaboration	3.68	VH
5. Allows students to talk to experts and conducts researches	3.64	VH
6. Demands students to become keen observers	3.64	VH
7. Let students to become dreamers	3.64	VH
8. Facilitates students to reiterate their works and prototypes	3.64	VH
9. Allows students to sketch their ideas	3.60	VH
10. Makes learning engaging and interesting	3.60	VH
11. Improves critical thinking ability	3.56	VH
12. Exposes students to deal and interact with people	3.56	VH
13. Immerses students in the problem scenario	3.52	VH
14. Gives opportunity for communication	3.52	VH
15. Engages students in hands-on design challenges	3.48	H
16. Encourages ideation	3.48	H
17. Allows students to ask questions and reflect on what they see	3.48	H
18. Allows students to determine early the weaknesses of the prototype and take actions immediately	3.48	H
19. Engages students in real-world projects	3.48	H
20. Develops a sense of empathy	3.44	H
21. Fosters active problem solving	3.44	H
22. Permits students to gather feedbacks	3.44	H
23. Welcomes all ideas	3.40	H
24. Develops student's creativity	3.40	H
25. Eliminates the fear of failure	3.28	H
Composite Mean	**3.54**	**VH**

Legend: WM – Weighted Mean, VI – Verbal Interpretation, H – High, VH – Very High

As a whole, composite mean of 3.54 indicates that the respondents have very high understanding and appreciation in the design thinking as an approach in the learning process most specially in understanding lessons in physics such as Newton's laws of motion, potential and kinetic energy, heat transfer, and electricity.

Instructional Guide Utilizing Design Thinking Approach

The study aimed to promote an innovative teaching strategy that will support effective learning of physics concepts. The researcher believes in the importance of physics in understanding the processes that occur in matter which comprises the natural world. In line with this goal is the purpose of providing instructional guide utilizing design thinking approach.

The proposed design thinking activities were based on the findings of the study that the students in the experimental group where design thinking approach was utilized, performed better than the students in the control group where traditional method of teaching was used. In line with this, the researcher has seen that design thinking approach helped the students to develop their skills along its phases.

The instructional guide focused on how design thinking can be utilized in teaching physics concepts to Grade 8 students. It includes lessons about

Newton's laws of motion, potential and kinetic energy, heat transfer and electricity that require students to be engaged in design challenges. Compared to other instructional guides, the lessons provided follow distinct phases such as empathizing, ideating, prototyping, and testing. As students work through each phase, their skills such as communication, collaboration, critical thinking, and creativity will be developed.

Moreover, this instructional guide is designed to help teachers, especially physics teachers in bringing innovation to the teaching-learning process by engaging students in a more interactive environment. Students will become part of a design challenge that promotes the development of 21st century skills.

VI. CONCLUSION

Comparable levels of performance were seen in the pre-test, while differences on the levels of performance were found in the post-test. Design thinking approach positively affects the levels of performance of students. The design thinking approach develops richly the varied skills related and can be developed in empathizing, ideating, prototyping and testing. Design thinking as an approach in learning physics is well understood and appreciated. The proposed instructional guide utilizing design thinking approach contains interactive activities that will engage students in design challenges following the four phases of design thinking.

VII. RECOMMENDATION

The output of this study is recommended for further review for the improvement of its contents after which the proposed instructional guide may be used by science teachers to enhance the teaching of physics concepts. Educators may shift from traditional methods of teaching through innovative strategies that will cater the needs of 21st century learners. A similar study on design thinking approach may be conducted focusing on other learning areas.

VIII. REFERENCES

[1] **Esiobu, G.O. (2005).** Genre Issues in Science and Technology Education Development, Science and Technology Education for Development, pp. (137-156).

[2] **Buabeng, Isaac, (2015).** "Teaching and Learning Physics in New Zealand High Schools," University of Canterbury, New Zealand.

[3] **Bodrova, Leong E. (2006).** Tools of the Mind: The Vygotskian Approach to Early Childhood Education, New Jersey:Prentice Hall.

[4] **Ray, B.,** Design Thinking: Lessons for the Classroom, (http://www.edutopia.org/blog/design-thinking-betty-ray), date retrieved: 2018

[5] **Baeck, A. & Gremett, P. (2012).** Design Thinking, New York: McGraw-Hill.

[6] **Dam, A.,** Stages in the Design Thinking Process, (https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process), date retrieved: 2018.

[7] **Creighton, Emma. (2017).** Learning through Design Thinking, National College of Art & Design, South Dublin County Council.

[8] **Ineta, Luka. (2014).** Design Thinking in Pedagogy, (https://www.researchgate.net/publication/280576280_Design_Thinking_in_Pedagogy) date retrieved:2019.

****