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The Synectics Teaching Method: Effects on the Problem- Solving and Creative Thinking Skills of Learners in Physics

Louie M. Valdez, PhD[1], Virginia S. Sobremisana, PhD[2]

[1]Master Teacher I, Muntinlupa National High School Tunasan Annex
louiemvaldez[at]gmail.com

[2]Professor, Rizal Technological University-Boni Campus

Abstract: ***The study focused on the effects of the synetics teaching method on the student's creative thinking and problem-solving skills in physics. The researcher used the quantitative research method, specifically the descriptive quasi- experimental design was employed to find out if the use of the synectics teaching method enhances the problem-solving and creative thinking skills of the Grade 12 students in physics. Intact groups were selected and then matched according to age, final grade in Physics 1, pre-test in problem-solving skills and pre-test in creative thinking skills. The post-test mean scores of the experimental and control groups are 17.52 and 14.90 respectively. The two groups in creative thinking skills slightly differed with 3.978 for experimental group and 3.61 for the control indicating an improved in creative thinking skills of the students. The difference in the pre-tests and post-tests scores of the two groups in the problem-solving skills test of the experimental group showed better improvement when synectics teaching techniques in the eight (8) modules were utilized. The p-value of 0.00243 indicates that the post test mean scores of the two groups differ significantly. The experimental group performs better than the control group in terms of Problem-Solving Skills. Finally, the relationship between problem solving skills and creative thinking skills of the experimental group revealed that the interaction between the creative thinking skills vis-à-vis problem-solving skills has low significant relationship as implied by the p-value of -0.045 indicating that the high problem-solving skills of the students varies inversely with the creative thinking skills.***

1. Introduction

Scientific competencies are a heritage of mankind. It is a treasure that serves as an equalizer in the disparity of educational achievement in the world's societies. It brings about an acceptable quality of life, progress and innovation in our daily lives. The world's educational system designed curricular programs and projects to sustain demand of the human environment emanating from the rapidly changing world. Science and Technology is central to meet the myriad of challenges stated in the Science Development Goals (SDG) focusing on the investments into scientific literacy and establishing sustainable consumption patterns (Goal 12) which means supporting developing countries to strengthen this scientific and technological capacities.

In science education, physics is perceived as a difficult course for students from secondary school to university and for adults in graduate education. It is well known that both high school and college students find physics difficult. That is why; the achievement in physics is very low (Cardona, Garcia and Ebojo, 2012; Mirasol, 2011).Students' problem-solving ability in physics has become the focus in some recent researches in the last decades. A good problem-solving framework was needed to build physics knowledge (Docktor, Strand, Mestre and Ross, 2015). Student attitude towards learning and problem solving in physics and their conception towards the purpose of learning physics could give a significant effect on what they are learning (Mason & Singh, 2016). Problem solving is very important part in scientific reasoning because the skills in problem solving gives effect to change and improve emotional, cognitive and psychomotor improvement (Alshamali& Daher, 2016). Although problem solving is one of the categories of thinking ability used by teachers to teach their students to think (Riantoni, Yuliati& Mufti (2017) and improve emotional, cognitive and psychomotor, the practice of problem solving is the main factor in physics education (Ceberio, Almudí, & Franco, 2016).

The students' lack in problem solving skills is due to their scant attention given to problem solving; in addition, they have a weak understanding of physics concepts and laws (Ceberio, Almudí, & Franco, 2016). In the learning process, the strategy which only focuses on how to solve a problem that needs mathematics calculation has become the cause of students' lack of problem solving skill (Sujarwanto & Hidayat 2014). Besides, many students also do not get well about the process in problem solving during learning (Brown, Mason, & Singh, 2016).

In the local scene, with the implementation of the Enhanced Basic Education Act of 2013 (R.A. 10533) in the Department of Education (DepEd), the Philippines at present, is faced with the challenges in the educational system. This was brought by the failure of the Department of Education to meet the educational standard of 75 % in the overall Mean Percentage of Score in the National Achievement Test in Elementary and High School over the past ten years (De Dios, 2013). The education system can activate the students to learn ways to reach knowledge, to develop solutions for problems yet unknown and to enhance the skills of decision-making (Ince Aka, Guven & Aydogdu, 2010). Science education reformers have supported the idea that learners should be engaged in the excitement of science, they should be helped to discover the value of evidence-based reasoning and higher-order cognitive skills and be taught to become innovative problem solvers (Perkins & Wieman, 2008).

Filipino teachers are continuously looking for strategies which can enable students to develop problem solving and creative thinking skills in Physics. One way to achieve this is through the use of synectics in teaching developed by William J. Gordon.Gordon named it the familiarity bleaching (Tajari & Tajari, 2011) in which a person tries to get familiar with new vision and creative thinking. This manner is formed by activities and metaphorical analogy (Tajari&Tajari, 2011).

Notable researchers have been oriented on the role of Synectics patterns in critical thinking, problem solving skills and its impact on creativity. Sedaghat, Darivash and Kashkooei (2015) evaluated the impact of a Synectics teaching pattern on improving the creativity in the composition of students. The result showed that using the Synectics teaching pattern is more effective than the traditional teaching method in improving the flexibility of the thinking of students in the composition study. Abed, Davoudi and Hoseinzadeh (2013) investigated the effects of the Synectics pattern on increasing the level of problem solving and critical thinking skills of students. The findings demonstrated that the Synectics pattern leads to an increase in the level of critical thinking and problem-solving skills.

Based on the facts provided, the Synectics teaching method is a new teaching method which develops the thinking and problem-solving capacity of students and creative expression of new ideas(Amir &Moktahab, 2011). But since there is deficiency of materials that can help students to learn more about physics, the researcher constructed instructional materials for Grade Twelve physics to somehow contribute to the scarcity of learning materials in the field. These materials incorporated the use of synectics techniques which is known as one of the creativity techniques popularly applied for problem solving approach studied by Chadrasekaran (2014) in the effectiveness of synectics techniques in teaching ofzoology in the secondary level.

This study sought to help students to understand the least learned competencies by developing, validating and testing the effects of synectics teaching in grade twelve students in physics through Synectics teaching model.

2. Theoretical Framework

This study is anchored on the Connectivism Theory by Siemens and Downs (2009)denouncing boundaries of behaviorism, cognitivism, and constructivism, which had very much influenced the teaching-learning scenario worldwide. Connectivism is characterized as a reflection of our society that is changing rapidly. Society is more complex, connected, socially, global, and mediated by increasing advancements in technology. It is the orchestration of a complex disarray of ideas, networked to form specific information sets. Ways of knowing are derived from a diversity of opinions. The individual does not have control; rather it is a collaboration of current ideas as seen from a present reality. The core skill is the ability to see connections between information sources and to maintain that connection to facilitate continual learning. Decisions are supported by rapidly altering fundamentals as new information is quickly integrated to create a new climate of thinking. This constant update and shift of knowledge can also be contained outside the learner, such as in a database or other specialized information source. For the learner, to be connected to this outside knowledge is more important than his or her existing state of knowing. The first point of connectivism is the individual. Personal knowledge consists of a system of networks, which supplies an organization, which in turn gives back to the system. The individual continues the cycle of knowledge growth by his or her access back into the system. The advantage is that the learner can remain current on any topic through the connections they have created. Within any defined social network, there is a focus for groups of people with a common goal. In other words, learners can promote and sustain a well-organized flow of knowledge.

Connectivism as a learning theory is characterized as the enhancement of how a student learns with the knowledge and perception gained through the addition of a personal network (Siemens, 2005).It is only through these personal networks that the learner can acquire the viewpoint and diversity of opinion to learn to make critical decisions. Since it is impossible to experience everything, the learner can share and learn through collaboration. Second, the sheer amount of data available makes it impossible for a learner to know all that is needed to critically examine specific situations. Being able to tap into huge databases of knowledge in an instant empowers a learner to seek further knowledge. Such a capacity to acquire knowledge can facilitate research and assist in interpreting patterns. Third, explaining learning by means of traditional learning theories is severely limited by the rapid change brought about by technology. Connectivism is defined as actionable knowledge, where an understanding of where to find knowledge may be more important than answering how or what that knowledge encompasses.

Similar to constructivism, the learner is central to the learning process in connectivism. However, the networking processes in connectivism add a dimension to the social context in which the collaborative activity, enhances knowledge construction (learning) in a slightly different way. Researches show that in constructivism, learning is determined by the complex interplay among learners' existing knowledge, the social context, and the problem to be solved.

Anchoring on Connectivism, the Synectics Theory holds that the real meaning in a statement comes from places other than the pure content words. The theory has a direct application to qualitative research, particularly when the objective of this research is conceptualized or synthesizedin a concept or idea from a body of materials on the subject at hand. Since, the current research is developing a Synectics Teaching Model, the theory suggests that the moderator or group leader in a conceptualization session will have to install a set of exercises or probes to extract true meaning from the statements of participants from inputs or stimuli such as subtest, diction, syntax, gesticulation and repetition.

Using the premises cited, there is a need to develop a material that would help in the teaching-learning process that are creative and appropriate for the learning needs of students in Physics. In this study, the utilization of Synectics Teaching Method can serve as a strategy in promoting functional physics literacy among learners. In this method, metaphor and analogy were used to enhance creative power of learners. Incorporating the comparing, classifying, metaphors, analogies and graphic organizers technique of Synectics, may help learners to process knowledge by making direct, personal and compressed- conflict analogies. There are three Synectics model: the original Synectics model, the corporate Synectics model and the K-12 Synectics Model (Gunter, Estes and Schwab, 2007). Primarily, this study anchored on K-12 Synectics Teaching Model in Physics would improve the problem-solving skills and creative thinking skills of senior high school students under Academic Track at Muntinlupa National High School.

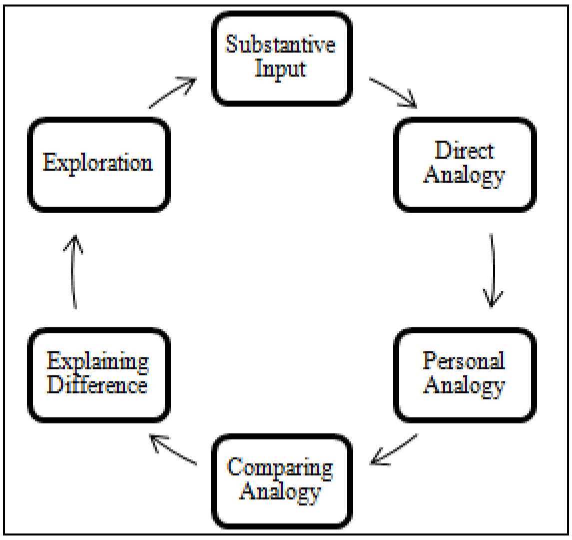

Figure 1: K-12 Synectics Model

Gunter ,Estes and Schwab (2007) described the components of the of the K-12 Synectics Model which are: *Substantive Input*, teacher provides information on new topic; *Direct Analogy*, teacher suggests direct analogy and asks students to describe the analogy; *Personal Analogy*, teacher has students "become" the direct analogy; *Comparing Analogy*, students identify and explain the points of similarity between the new material and the direct analogy; *Explaining Difference*, students explain where the analogy does not fit; *Exploration*, students re-explore the original topic on its own terms

3. Conceptual Framework

The schematic diagram shows the relationships among variables. The variables are categorized as Independent and Dependent Variables. The Independent variables are composed of treatment variables (experimental variable) and control variables. The experimental variables may affect the learners' problem-solving skills and creative thinking skills towards Physics and that, applying the Synectics Teaching Method can have a significant effect on the problem-solving skills and creative thinking skills of the students in Physics. The methods of teaching (traditional method and Synectics teaching method) are the treatment variables. It suggests that the Problem-Solving and Creative Thinking Skills are dependent variables.

It assumes that the use of the Synectics Teaching Method is effective in enhancing Physics Problem Solving Skills and Creative Thinking Skills in Physics as presented in Figure 2.

4. Conceptual Model

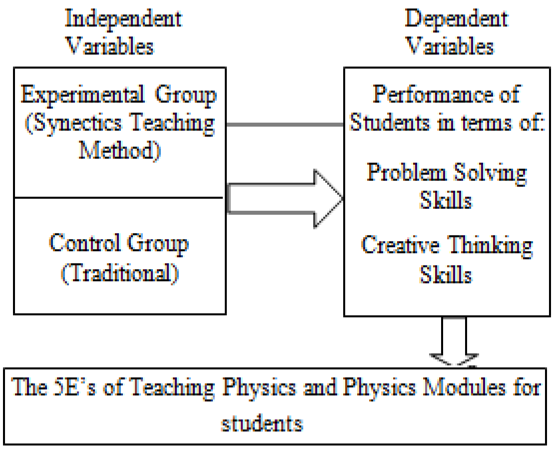

Figure 2: Conceptual Model

The conceptual model shows the relationships among the variables: the Independent and Dependent Variables. The independent variables are the teaching strategies utilized by the researcher in the conduct of the study. The experimental group was exposed to the use of Synectics in which the teacher provides information on a new topic; teacher suggests direct analogy and asks students to describe the analogy; teacher has students "become" the direct analogy; students identify and explain the points of similarity between the new material and the direct analogy; students explain where the analogy does not fit; students re-explore the original topic on its own terms, while the traditional group will be the group that makes use of the chalk and board techniques. This study aimed to measure the effect of the use of the Synectics teaching method in the problem-solving and creative thinking skills of the students in Physics.

5. Statement of the Problem

This study aimed to determine the effects of the Synectics Teaching Method on the Problem-Solving and Creative Thinking Skills in Physics among Grade 12 Senior High School students in the City of Muntinlupa for the 2nd Semester A.Y. 2018-2019.

Specifically, the study sought to answer the following questions:
1) What are the pretest and posttest mean scores of the Experimental and Control Groups in Problem-Solving Skills Test (PSST)?
2) What are the pre and post assessments of the Experimental andthe Control Groups in their Creative Thinking Skills?

3) What is the difference in the pre-test and post-test mean scores in Problem- Solving Skills Test of the Experimental and Control Groups?
4) What is the difference in the pre-assessment and post-assessment in Creative Thinking Skills of the Experimental and Control Groups?
5) What is the difference in the post-test mean scores in Problem- Solving Skills Test of the Experimental and Control Groups?
6) What is the difference between the post- assessments in Creative Thinking Skills of the Experimental and Control Groups based on the identified components?
7) What is the relationship on the assessment between Problem-Solving Skills Test and Creative Thinking Skills of the Experimental Group?
8) What teacher's guide maybe developed to improve the problem-solving skills and creative thinking skills of the students using the Synectics teaching method?

Hypotheses of the Study

The research tested the following null hypotheses for acceptance or rejection:

1) There is no significant difference between the pre-test and post-test mean scores in Problem Solving of the Experimental and Control Groups.
2) There is no significant difference between the post-test mean scores of the Experimental and Control Groups.
3) There is no significant difference between the pre-assessment and post- assessment in Creative Thinking Skills of the Experimental and Control Groups.
4) There is no significant difference between the post-assessments in Creative Thinking Skills of the Experimental and Control Groups based on the identified components.
5) There is no significant relationship on the assessment between Problem Solving Skills and Creative Thinking Skills of the Experimental Group.

Scope and Delimitations of the Study

This study determined the effects of the use of the Synectics Teaching Method as a factor that might increase the problem-solving and creative thinking skills aside from critical thinking skills of the students toward Physics. The study involved the selected Grade 12 Senior High School students of Muntinlupa National High School, Muntinlupa City. The time frame for the study was the Second Semester of the School Year 2018-2019. The development of the Synectics Teaching Method was limited to topics that were based on the results of the reported least mastery level in Physics of the students in the Division of Muntinlupa. The study used the Control Group and the Experimental Group consisting of 31matched pairs based on Physics 1 General Average, Age, Gender and Pre-Test Scores. The study was conducted to improvise instructional materials that would respond to the inadequacy of the existing learning resources of many public secondary high schools. It will also measure how effective the use of a teaching strategy called Synectics Model in enhancing the Problem Solving and Creative Thinking Skills of the Students.

Research Method

The researcher used the descriptive-quantitative research method, specifically the quasi- experimental design. The pretest-posttest non-equivalent group designusing matched subjects (Fraenkel & Wallen, 2009)with a Control Group and an Experimental Group was used to determine the intervening factor of a teaching method as a better method of teaching the course Physics. The Control Group used the traditional method of teaching while the Experimental Group used Synectics as a strategy in teaching Physics.

The study followed the matching or equating the groups, where the Control Group and the Experimental Group were set initially alike or parallel in terms ofAcademic Grade in Physics 1, Age, Gender, Schedule of Classes, and Teacher.

Treatment Group	M	O_1	X	O_2
Control Group	M	O_3	C	O_4

Figure 3: Pretest-PosttestControl Non-Equivalent Group Design, using Matched Subjects

Where: M represents that the groups are non-equivalent
X is the administration of Synectics Teaching in Physics
C is the administration of Traditional Teaching in Physics
O_1 and O_3 are the pretest of the control and experimental group
O_2 and O_4 are the post-tests of the control group and experimental group

6. Research Instruments

Validation of Problem-Solving Test

Quantitative Problem Solving involves formulas and solving problems quantitatively (Argaw, Haile, Ayalew& Kuma, 2017).The test was constructed based on the Table of Specification. Three physics instructors were requested to face, and content validate the said test in the following topics 1) Nature of Light, 2) Reflection of Light, 3) Mirror Images formed by Plane Mirror, 4) Curved Mirror, 5) Images formed by curved Mirror, 6) Refraction of Light Rays (Index of Refraction), 7) Anatomy of Lens (Focal Length and Power of the Lens), 8) Refraction of Light in Lenses (Image Formation in Lenses), 9) Refraction of light in Lenses (Constructing Images Formed in Lenses). These topics were the least mastered competencies of physics students based on the Division Performance Summary per quarter.

Qualitative analysis was determined whether or not the test questions were appropriate as pretest for the Grade 12 learners in terms of clarity of options, significance of concept, simplicity of responses, appropriateness of vocabulary and similarity of options. Corresponding revisions were made based on their comments and suggestions. After a slight modification following their suggestions, the test was administered to thirty (30) Grade 12 students who took Physics Subject. This test was item analyzed using the U-L Index method and was validated by Physics instructors from Muntinlupa National High Schooland experts who were a STEM-Teacher III, STEM-Master Teacher I at Muntinlupa National High School andDivision Science Supervisor in the Division of Muntinlupa.

The researcher followed the procedure in item analysis for the Problem Solving Test. 1) Score each Problem Solving Test. 2) Sort the papers in numerical order according to the total score, highest to lowest. 3) Determine the upper 27 % and the lower 27 % groups. “Maximally reliable item discrimination results will be obtained when each criterion group contains 27% of the total.” (Kelly, cited by Valdez, 2014). 4) Record separately the number of times each alternative was selected by individuals in the high and low groups. Some questions were deleted/discarded because they were either too difficult or too easy. There were thirty (30) items under revised/rejected, thirty-three (33) items that were good items and twelve (12) items which were interpreted as very good items. In the end, forty-five (45) questions were left in the test. To establish the reliability of the instrument, test-retest was used with another section who is taking up Physics which comprise of 30 students. The reliability of the Problem-Solving Skills test was calculated using the Kuder-Richardson (KR-20) Formula. The reliability value obtained was 0.87.

Apparatus Used in the Activities on Synectics

The instructional materials to be organized should support, enrich and extend the school’s curriculum and to encourage informational, educational and recreational reading, viewing and/or listening (Marbas, and Pelley 2015). There are important factors to be considered in constructing an effective instructional material. This includes diverse user interests, abilities, backgrounds, cultures, languages, and maturity levels. Materials intended for student use should be appropriate for the subject area and for the age, social development, ability levels, special needs, and learning styles of students served. As planning the instructional activities, the researcher gathered additional insights on the preparation of the materials specifically on content and on how to use Synectics through reading, surfing the net, selecting of books and other reference materials in physics.

The laboratory devices used by the researcher in this study during the lesson executions include: protractor, ruler, push pins, graphing paper, cheap commercial laser, glass plate, ball and flat mirror. These readily available localized and indigenized material was used in Module 1. In Module 2 and 3, same materials were used with the addenda of clear glass, toy car/marching band. In Module 4 and 5, plane mirror, concave mirror, convex mirror, spoon, bowl and flashlight were utilized to perform the activity. The convex lens, concave lens, push pins, graphing paper, playing cards, cheap commercial laser were the materials used to conduct the activities in module 6, 7 and 8. The researcher engaged the help of three physics instructors to validate the said activities and instruments. Corresponding revisions were made based on their comments and suggestions.

Creative Thinking Skills Test

The creative thinking skills test was adapted from the study of Talens (2016) about the influence of problem-based learning on the creative thinking skills of physical science students of De La Salle Lipa. The said instrument is made up of 48 indicators using the Likert Scale with four main indicators of manifestation of creative thinking skills such as originality (15 indicators), fluency (14 indicators), flexibility (8 indicators) and elaboration (11 indicators). The continuum and interpretation below were used to interpret the result.

4.50 – 5.00 Manifested with very great extent
3.50 – 4.49 Manifested with great extent
2.50 – 3.49 Manifested to a moderate extent
1.50 – 2.49 Manifested to a least extent
1.00 – 1.49 Poorly manifested

Synectics Lessons

Synectics Teaching Methods in this study pertain to the developed materials used in teaching the experimental group of the concepts about lights and optics. To validate the teacher’s guide with Synectics teaching, the researcher consulted his adviser, Division Science Coordinator of Muntinlupa City, STEM Coordinator of Muntinlupa National High School-Main and a Head Teacher III at Muntinlupa National High School Annex. The Quality Review for the Instruments used byBuna (2016) was adapted as an instrument to measure the quality of the instructional materials.

The questionnaires are Likert Type Scale with the following ranges and interpretations:

3.50 – 4.00	Very Satisfactory
3.00. – 3.49	Satisfactory
2.00 – 2.49	Poor
1.00 – 1.49	Not Satisfactory

The steps followed in delivering the synectics/analogies are: (1) introduce students to the unfamiliar concepts, (2) remind students of a familiar concept (3) compare and contrast the features of the two concepts, and (4) draw conclusion about the analogy and highlight the overall similarities between the two concepts.

The Synectics Teaching uses delivery strategies such as lectures, demonstrations, guided discussions, inquiries and learning. The learning or scaffolding activities which were given to the experimental group are experiments, puzzles, games, simulations, science magic tricks, POE (Predict, Observe, and Explain), graphic organizers, video integration, quizzes and performance activities. These activities will be broadly applied to equip students to engage with develop and demonstrate the desired understanding.

There are eleven (11) instructional analogies that were embedded in the lesson plan of the experimental group.The 5 E's instructional model based on the constructivist approach to learning lesson plan in which instructional analogies were embedded and served as the guide in teaching. Each of the 5 E's describes a phase of learning, and each phase begins with the letter "E": Engage, Explore, Explain, Elaborate, and Evaluate.

Data Gathering Procedures

Prior to the study, are quest letter to conduct the experiment was addressed to the Schools Division Superintendent through the Principal of the School. Upon the approval of the request and after identifying the students’ needs in terms of curriculum content, the Physics Problem Solving Test instrument was developed which was validated by experts who are knowledgeable in research and Science Curriculum.

To gather the reliable data needed in the conduct of the experiment, the problem-solving test consisting of 75 items of an objective type of test covering the learning competencies was used. The test was content-validated by experts in test preparation. A suggestion provided by the experts was taken into consideration. Creative Thinking Skills Assessment is another instrument that was used in the study.

Pilot testing of the problem solving-test instrument was done to thirty (30) Grade 12 students. The test results were used to improve the test items and to identify which items are to be rejected, revised or retained. Before the experiment, two groups were purposively selected and matched. The first group was exposed to the Synectics teaching method and the second group used the traditional teaching methods in which the teacher acted as facilitator of learning. After each teaching methods were applied posttest was given to determine the level of problem-solving skills and creative thinking skills assessment of the two groups of respondents. The data obtained in the posttest were subjected to statistical test to measure the significant difference between the pre-test and posttests. Table 3 shows the conduct of the study.

Statistical Treatment of Data

The researcher also used the following inferential statistics:

1) The significant difference in the mean scores of the pre-test and post-test of the two groups in the problem-solving skills test were analyzed using the **t-test for independent sample means.** The same test was used to test significant difference between pre-assessment and post-assessments in creative thinking skills of the experimental and control groups as well as the difference in the post-test scores in the problem-solving skills and creative thinking skills.
2) To determine the strength of the linear relationship or association between the problem solving and creative thinking skills, the **Pearson-Product moment of Correlation Coefficient** was used. The Microsoft Excel for Windows was used in performing to get the mean scores of the data that was gathered in this study and the rest of the statistical test was manually computed by the researcher.

7. Presentation, Analysis and Interpretation of Data

1) The Pretest and Posttest Mean Scores in Problem-Solving Skills Test (PSST)

Table 4 below shows the mean scores of the students taught using the Synectics teaching model and those who were taught using traditional teaching method.

Table 4: Mean Scores in the Pretests and Posttests of the Two Groups in Problem-Solving Skills Test

Group	Test	Mean	Sd	Mean Difference	N
EG	Pretest	12.29	2.83	1.0	31
CG	Pretest	11.29	2.16		
EG	Post-test	17.52	3.68	2.62	31
CG	Post-test	14.90	2.71		

Legend: EG-experimental group, CG-Control group, SD-Standard deviation

The data reveal that the pre-test mean score, $\bar{X}$ = 12.29, of the experimental group ishigher than the control group with a mean score of $\bar{X}$ = 11.29. However, it is also apparent that the pretest scores of the two groups were slightly parallel to each other with a mean difference of only 1.0. It was also noticed that the scores of the experimental group were more dispersed which may be due to the heterogeneity of the students admitted in every class. This is the reason why they were matched.

The result conforms to the study of Rivera (2014) on the effects of multimedia in enhancing Science performance and motivation of the students toward the Science Subject and the study of Valdez (2014) on the effects of analogy-enhanced instruction on students' achievement and attitude towards physics where two groups were matched before the intervention was employed.

Table 4 also presents the post-test mean scores of the two groups in the problem-solving skills. The experimental group has a higher post-test mean scores of $\bar{X}$ =17.52 as compared with the control group, mean scores of $\bar{X}$ =14.90. Based from the result, it could be noted that the experimental group performs better than the control group. Furthermore, the scores of the experimental group are more dispersed with a standard deviation of 3.68 than that of the control group with a standard deviation of 2.71.

With the above statistics in consideration, Synectics model used by the researcher is in conjunction with the works of Talwar and Sheela (2004) which says that it was more effective in developing creativity and problem solving. The idea presented from the investigation supports the result of this study that Synectics can really improve the problem-solving skills of respondents. Moreover, the post-test results of the two groups show their improved performance from the pretest. This can be supported with the idea of Abed, Davoudi and Hoseinzadeh (2013) that Synectics pattern can leads to the increase of problem-solving skills in students and its dimensions (trust on problem-solving, tendency-avoidance in problem-solving and personal control in problem solving).

Evidently, theSynectics teaching method can improve the problem-solving skills of students in physics, specifically in lights and optics. Thus, this method will also cause an increase in the attainment of competencies in some physics topics.

2) Pre and Post Assessments of the Experimental and Control Groups in their Creative Thinking Skills

The pre-assessment and post-assessment of the two groups in their creative thinking skills in the different components of originality, fluency, flexibility and elaboration are shown in Table 5.

Data in Table 5 show that the control group garnered a higher mean score than the experimental group in the originality skills with 3.5 and 3.18, respectively. On the fluency skills, the experimental group has a higher mean of 3.43 than the control group with a mean score of 3.24. In the flexibility skills, 3.27 and 3.35 were recorded in which the control group got a higher mean than the experimental group. Similar results also on elaboration skills with a mean of 3.00 and 3.40 for the experimental and control group, correspondingly. The over-all weighted mean shows that the control group has a higher mean of 3.37 than the experimental group which has a mean of 3.22. Nevertheless, the mean of the two groups were interpreted as manifested to a moderate extent only

Table 5: Pre-Assessment and Post-Assessment of the Two Groups in Creative Thinking Skills Test

Skills	Pre-Assessment				Post-Assessment			
	Experimental Group		Control Group		Experimental Group		Control Group	
	Mean	VI	Mean	VI	Mean	VI	Mean	VI
Originality	3.18	Manifested to a moderate extent	3.5	Manifested with great extent	3.95	Manifested with great extent	3.82	Manifested with great extent
Fluency	3.43	Manifested to a moderate extent	3.24	Manifested to a moderate extent	3.93	Manifested with great extent	3.43	Manifested to a moderate extent
Flexibility	3.27	Manifested to a moderate extent	3.35	Manifested to a moderate extent	4.12	Manifested with great extent	3.58	Manifested with great extent
Elaboration	3	Manifested to a moderate extent	3.4	Manifested to a moderate extent	3.91	Manifested with great extent	3.62	Manifested with great extent
Grand Mean	3.22	Manifested to a moderate extent	3.37	Manifested to a moderate extent	3.98	Manifested with great extent	3.61	Manifested with great extent

Legend: EG-experimental group, CG-Control group, VI-Verbal interpretation

Both groups were at the same level, just like what was emphasized in the study of Valdez (2014) and Rivera (2014) in which purposive sample selection has been accurately done to produce an accurate result. Furthermore, Valdez (2014) cited Shuttleworth (2009) that in an experimental study, threats could be minimized by equating the two groups.

It can be inferred from Table5the mean scores in the post-assessment of the two groups in creative thinking skills test. In experimental group, the creative thinking skills were manifested with great extent with an overall mean of 3.978. The students in the experimental group have “manifested with great extent” in all creative thinking skills namely: Flexibility with a mean of 4.12 followed closely by Originality with a mean of 3.95 while Fluency and Elaboration have a mean of 3.93 and 3.91 respectively but both still fall under the verbal interpretation of “Manifested with great extent”.

On the other hand, the control group has also shown great extent in Creative Thinking Skills with an overall mean of 3.61 or “Manifested with great extent”. To exemplify further, the students in the control group manifested great extent in all areas of the creative thinking skills as shown in the individual mean scores. For the control group, Originality Skills is the highest from all the areas with a computed mean of 3.82 or “Manifested with great extent” followed by Elaboration with a mean of 3.62 which can interpreted as “Manifested with great extent”, next is Flexibility with a mean of 3.58., while the last is Fluency with a computed mean score of 3.43 with a verbal interpretation of “Manifested to a moderate extent”.

In comparison, the experimental group is higher than the control group in all areas of creative thinking skills namely: originality, fluency, flexibility, and elaboration. Thus, it is established from the result of the data gathered that synectics can really improve the creative thinking abilities of the students.

The above results conformed with the study of Tajariand Tajari(2011), where the Synectics teaching and lecture methods were compared. The results revealed that teaching by Synectics method not only will increase the creativity about fluency, originality, flexibility and elaboration, but also will increase individual differences.

It can be concluded therefore that there is an increase the creative thinking skill among students exposed to synectics method of teaching.

3) Difference in the Pretest-Posttest Scores in Problem-Solving Skills Test (PSST) of the Experimental and Control Groups

Table 6 presents the difference in the pretest and post-test scores of the experimental group in Problem-Solving Skills Test.

Table 6: Difference in the Pretest-Posttest Scores in Problem-Solving Skills Test of the Two Groups

Group	Test	Mean	Sd	D	T	Probability Value *(p<0.01)	Interpretation
EG	Pretest	12.29	2.83	4.62	6.25	4.05E-8	*S
	Posttest	17.52	3.69				
CG	Pretest	11.29	2.16	3.61	2.39	2.7E-07	*S
	Posttest	14.90	2.71				

Legend: EG-experimental group, CG-Control group, S-significant, p-probability=0.01, d-difference, SD-Standard deviation

Data show that the experimental group who were exposed to Synectics teaching method has a pretest mean scores of 12.29 and a posttest mean scores of 17.52 with a mean difference of 4.62.When this mean difference (d) of 4.62 was tested for significance a computed t-value of 6.25 was derived revealed a very significant difference with a probability of 4.05E-08 which is less than the ά=0.01. The experimental group also showed better improvement in problem-solving skills using synectics techniques in teaching physics concepts utilized in the study. These findings of the study for profoundly supported the works of other researchers.

For instance, Wong as cited by Ugur, Dilber, Senpolat, and Duzgun (2008), considered that generative analogies are dynamic tools that facilitate understanding, rather than representations of the correct and static explanations or solution. Synectics Teaching able to facilitate understanding of new concepts by comparing and contrasting their features to existing conceptual knowledge in mind of the learner (Remigio, 2012).

Moreover, the use of synectics as a method in teaching physics with incorporation of problem-solving skills is effective. This result is also supported in the studies conducted by Talwar and Sheela (2004), Curtis (2008) and Abed, Davoudi and Hoseinzadeh (2013).Therefore, the synectics method can improve the problem-solving skills of students in phyiscs specifically in Lights and Optics.

The record shows that the members of the control group obtained a pretest mean score of only 11.29 points problem-solving skills test in Physics. This however improved through the teaching of the subject using the traditional method of lecture, drill and recitation. They increased their knowledge in Physics and after the course was over and given the same as a posttest, they obtained a higher mean score of 14.90. This showed an increase of only 3.61. When the mean difference (d) of 3.61 was tested for significance by a dependent t-test, the computed t-value was 2.39 which means that the difference is significant. Although the increase was minimal, the performance as reckoned by the t-test was still significant considering the difficulty of the subject matter and the method of teaching was traditional.

The findings of the study is similar to that by Yacap, as mentioned by Palomares (2010) that performance of high school students in Physics is below average and by the results in the pretest and post-test for the mean gains were very small.

4) Difference in the Pre-Assessment and Post-Assessment of the Two Groups in their Creative Thinking Skills

Table 7 illustrates the computed t-value of the pre-assessment and the post-assessment scores of the experimental group. It shows further the standard deviation, the p-value and the corresponding interpretation.

Table 7 shows that there is significant difference between the pre-assessment and post-assessment of the creative thinking skills of the experimental group and the control group. To elucidate further, the computed p-values in Originality (t= 6.47, p=5.2E-07), Fluency (t= 4.83, p=5.2E-05), Flexibility (t= 8.75, p=4.7E-07), and Elaboration (t= 10.13, p=6.8E-08) were all below the significance level.

This leads to the rejection of the null hypothesis. This means that there is a significant difference between the pre-assessment and post-assessment in creative thinking skills such as originality, fluency, flexibility and elaboration of the experimental group. The result led to the conclusion that students exposed to synectics improved their creative thinking skills (originality, fluency, flexibility and elaboration).

Table 7: Difference in the Mean Scores in the Pre-Assessment and Post-Assessment of the Two Groups in Creative Thinking Skills Test

Group	Skills	Pre-Assessment	Post-Assessment	T	p-value	Interpretation
EG	Originality	3.18 (sd=0.37)	3.95 (sd=0.26)	6.47	5.2E-07	*S
	Fluency	3.43 (sd=0.35)	3.93 (sd=0.15)	4.83	5.2E-05	*S
	Flexibility	3.27 (sd=0.18)	4.12 (sd=0.2)	8.75	4.7E-07	*S
	Elaboration	3.00 (sd=0.17)	3.90 (sd=0.24)	10.13	6.8E-10	*S
CG	Originality	3.5 (sd=0.28)	3.82 (sd=0.32)	2.5	0.018	NS
	Fluency	3.24 (sd=0.22)	3.43 (sd=0.14)	2.55	0.017	NS
	Flexibility	3.35 (sd=0.22)	3.58 (sd=0.1)	3.56	0.02	NS
	Elaboration	3.40 (sd=0.14)	3.62 (sd=0.1)	2.02	0.05	NS

Legend: EG-experimental group, CG-Control group, NS-not significant, p-probability, d-difference, SD-Standard deviation

According to Reinhardt, Stacy and O'hair (2011),synectics can improve creative thinking skills. These are the benefits of synectics to creative thinking skills a) helps learners move their thinking from literal, to non-literal, allow for creative thinking; b) by identifying similarities and differences, learners enhance their understanding of the ability to use knowledge; c) gives learners more enriching projects by providing them another form of representation for learning; d) enhances learners understanding through representing similarities and differences in graphic or symbolic form; e) develops learners' ability to think creatively because it can deliberately force strange things together to form uncommon connections; f) allows learners to be creative in their learning; and lastly g) stimulates the learners to see and feel the original idea in fresh new ways.

The creative thinking skills namely: Fluency, Flexibility, Originality and Elaboration were interpreted as not significant when compared in terms of the pre-assessment and post-assessment within the control group.

To illustrate further, the computed t- values for each of the skills were as follows: Originality (t-value=2.05), Fluency (t-value= 2.55), Flexibility (t-value= 3.56), and elaboration (t-value= 2.02) which corresponds to the computed p-values 0.018, 0.017, 0.02, and 0.05 respectively.

Since the computed p-values were all above the threshold level of 0.01 or at 99% confidence interval, the null hypothesis is accepted, implying that there is no significant difference between the pre-assessment scores and post-assessment scores in creative thinking skills of the respondents in the control group.

This means that students who were not exposed to Synectics as a method in teaching did not improve in their creative thinking skills. The mean increases in each skill maybe accounted to other subjects which the control groups are exposed to since they are not exposed to any experimentation. This study supported the idea of Fatemipour and Kordnaeej (2014) that students exposed to Synetics developed a positive effect in students' creativity and outperformed the other who were not exposed to Synectics.

5) Difference in the Posttests Mean Scores of the Two Groups in Problem-Solving Skills Test (PSST)

Table 8 presents the t-value obtained in the post-test scores of the experimental group and control group.

Table 8: Difference in the Posttests Mean Scores of the Experimental Group and Control Group in Problem-Solving Skills Test (PSST)

Group	Test	Mean	Sd	D	T	Probability Value *(p<0.01)	Interpretation
EG	Posttest	17.52	3.69	2.62	3.18	0.00243	*S
CG	Posttest	14.90	2.71				

Legend: EG-experimental group, CG-Control group, NS-not significant, p-probability, d-difference, SD-Standard deviation

To test the significant difference between post tests scores of the experimental and control groups, data were subjected to t-test for independent samples with 99.99% confidence interval.

The experimental group has post test mean score of 17.52 while the control group has 14.90 posttest mean score. With this, the significant difference is 2.62 which resulted to a t-value of 3.18 and a p-value 0f 0.00243. Since the computed p-value is lower than the 0.01 level of significance, this led to the rejection of the null hypothesis. This means that there is a significant difference between the experimental and the control groups posttest scores.

Therefore, it can be concluded that students exposed in Synectics method in teaching physics performed better in problem-solving skills than those who are not. It can also be inferred from the result that Synectics can improve the problem-solving skills of the students in lights and optics.

Same findings were demonstrated in the study of Abed, Davoudi and Hoseinzadeh (2013), which include synectics is a pattern leads to increase the problem-solving skills in students and its dimensions (trust on problem-solving), tendency-avoidance in problem-solving and personal control in problem solving.

6) Difference Between the Post-Assessments of the Two Groups in their Creative Thinking Skills

Table 9 demonstrates the post-assessments of the experimental group and the control group in the creative thinking skills. The t-test for independent samples was used.

Table 9 reveals that post-assessment in creative skills is significantly different between the experimental and control groups. For Originality, the computed t-value for the experimental (Mean=3.95) and control group (3.82) yielded 1.21. This suggests the acceptance of the null hypothesis since the computed p-value is higher than the threshold value of 0.01. This means that that there is no a significant difference between the groups in terms of originality as creative thinking skill.

A similar result was observed in elaboration where the computed t-value for the experimental (Mean= 3.91) and control group (3.62) of 2.253 was obtained or p-value of greater than 0.01. This signified acceptance of the null hypothesis. Either which, it implies that there is no significant difference between the experimental and the control groups in terms of creative thinking skill under elaboration component.

Table 9: Difference in the Mean Scores in the Post-Assessments of the Two Groups in Creative Thinking Skills Test

Skills	Group	Post-Assessment	Sd	T	Significance p-value (p - 0.01)	Interpretation
Originality	EG	3.95	0.26	1.29	0.51	NS
	CG	3.82	0.1			
Fluency	EG	3.93	0.169	8.16	1.12E-08	*S
	CG	3.43	0.14			
Flexibility	EG	4.12	0.10	6.65	3.6E-05	*S
	CG	3.58	0.11			
Elaboration	EG	3.91	0.24	2.353	0.02955	NS
	CG	3.62	0.1			

Legend: EG-experimental group, CG-Control group, NS-not significant, p-probability, d-difference, SD-Standard deviation

Moreover, the null hypothesis is rejected in fluency since the computed t-value was 8.61 or a p-value of 1.12E-08 which is less than 0.01 level of significance, thus it was interpreted as significant. Similarly, flexibility component as shown in the computed t-value of 6.65 which can be translated as p-value of less than 0.01 denoted a significant difference between the means of the two groups. Rejection of the null hypothesis implied that there is a significant difference between the groups in terms of fluency and flexibility.

A similar study conducted by Zahra, Yusoo and Hasim as cited by Gencer and Gonen (2015) also yielded parallel results. In their study, the researchers worked with 60 preschoolers, and investigated the effects of creative instruction by exposing the experimental group to techniques such as narration, brainstorming, role playing and online searches. They also used pre- and post-project Torrance Creative Thinking Skills, testing with both the experimental and control groups, which indicated a significant increase in the test scores for the experimental group without a significant increase in the test scores of the control group. Another study by Dziedziewicz, Oledzka and Karwowski (2013) titled "Developing 4 to 6-year old children's figural creativity using a doodle-book program" also yielded significant differences in Fluency between the pre- and post-project Torrance Creativity Test scores. Yet another similar study by Karataş and Ozcan (2010) found significant increase in Fluency, Originality and Elaboration scores of two groups after exposure to information technologies instruction and creative information technologies instruction. The authors of the study reached the conclusion that the students in the group exposed to creative information technologies instruction scored higher in Fluency, Originality and Elaboration than those students who were exposed to information technologies instruction. Finally, Karakuş as cited by Gencer and Gonen (2015) investigated the creative problem-solving program's effect on creative thinking skills and found significant differences in various subscales of creative thinking in favor of the experimental group.

Furthermore, Paltasingh (2008) concluded that there was a significant difference between the effects synectics model and traditional method of teaching life science in development of creative thinking ability of learners. The training in creativity by teaching through the synectics model produced significantly higher achievement in science.

7) Relationship on the Assessment Between Problem Solving Skills and Creative Thinking Skills of the Experimental Group

Table 10 illustrates the relationship between the problem-solving skills and creative thinking skills of the experimental group in physics.

Table 10: Relationship between Assessment on Problem Solving Skills and Creative Thinking Skills of the Experimental Group

Variables	Mean	Computed r-value	Probability Value *(p<0.01)	Interpretation
Problem-Solving Skills	17.52	-0.04	-0.045	Not Significant, NS
Creative Thinking Skills	3.97			

Legend: EG-experimental group, CG-Control group, NS-not significant, p-probability, d-difference, SD-Standard deviation

Table 10 presents the computed value of r for the over-all assessment of the students in the creative thinking skills and their problem-solving skills. The computed r-value = - 0.04 tells that there is a negligible negative relationship between the variables.

As to the interaction between the creative thinking skills vis-à-vis problem-solving skills, no significant interaction exists as implied by the p-value of -0.045 which leads to the acceptance of the null hypothesis.

The result of the study contradicts with the study of Wright (as cited by Birgili 2015). According to a set of skills, creative thinking is distinct from analytical and practical thinking. Choices and critical evaluations, however, are made by participants and observers as a part of creativity process. Wright (as cited by Birgili 2015) points out that creativity integrates both problems setting and problem-solving skills with meaningful solutions.

This study now supports the idea of Bennis and O'Toole, 2005; Ghoshal, (2005), where emphasis is placed on left hemisphere brain activities of rational reasoning, mathematics and economics (analysis and implementation) and on the right right-hemisphere brain activities that include intuition and creativity (Maranville, 2011).

8) Developed Teacher's Guide toImprove the Problem-Solving Skills and Creative Thinking Skills of the Students using Synectics Teaching Method

The learning modules has the following parts: 1) Content Standard, 2) Performance Standard, 3) the Learning Competencies, 4) Pre-Test which measures the prior knowledge of the learners 5) Content with the incorporation of 5 E's (Engage, Explore, Explain, Elaboration and Evaluation) in teaching physics concepts and lastly the Post-Test and references. The summarized development guides by the researcher were in Appendix N. Based on the findings of the study, the Instructional Module with Synectics Teaching in Physics developed by the researcher is one of the alternative instructional materials in enhancing students' problem-solving skills and creative thinking skills. The learning guide with 5 E's in teaching serves as reference for Senior High School teachers who will be using the instrument.

8. Summary of Findings

The findings of the study are summarized as follows:

1) **The Pretest and Posttest Mean Scores in Problem-Solving Skills Test (PSST)**

The pre-test mean scores and post-test mean scorein the problem-solving skills test of the students exposed to Synectics was 12.29 and 17.5which was higher than the students in the traditional method with a mean of scores of 11.29 and 14.90, respectively.

2) **Pre and Post Assessments of the Experimental and Control Groups in their Creative Thinking Skills**

The pre-assessment in the creative thinking skills of both groups was 3.37 and 3.22 with a verbal interpretation of "manifested to a moderate extent". The post-assessment of the experimental group in the creative thinking skills were manifested with great extent with an overall mean of 3.978. While the traditional group had also showed great extent in Creative Thinking Skills with an overall mean of 3.61 or "Manifested with great extent".

3) **Difference in the Pretest-Posttest Scores in Problem-Solving Skills Test (PSST) of the Experimental and Control Groups**

When the data in experimental group were tested for significance, a computed t-value of 6.25 and p-value of less than 0.01 were derived which reckoned the mean difference as highly significant at 0.01 alpha level. While the control group, the record shows that the members of the control group improved through the teaching of the subject using the traditional method. Although the increase was minimal, the performance as reckoned by the t-test was still significant considering the difficulty of the subject matter and the method of teaching was traditional.

4) **Difference in the Pre-Assessment and Post-Assessment of the Two Groups in their Creative Thinking Skills**

The pre-assessment and post-assessment of the creative thinking skills of the students exposed to Synectics were all below the significance level at 0.01indicating that the null hypothesis is rejected. There is significant difference between the pre-assessment and post-assessment in creative thinking skills such as originality, fluency, flexibility and elaboration of the experimental group. While the originality, fluency, flexibility and elaboration component skills of the traditional group were interpreted as not significant in the pre-assessment and post-assessment in creative thinking skills. Since the computed p-values were all above the threshold level of 0.01 or at 99.99%

5) **Difference in the Posttests Mean Scores of the Two Groups in Problem-Solving Skills Test (PSST)**

The mean difference of 2.62 resulted to a computed t-value of 3.18 and a p-value 0f 0.00243. The post-test mean scores of the two groups differ significantly.

6) **Difference Between the Post-Assessments of the Two Groups in their Creative Thinking Skills**

The post-assessment of the two groups differed significantly with computed t-values in the creative thinking skills. For originality and elaboration, obtained a p-value of greater than 0.01.Moreover, the null hypothesis is rejected in fluency and flexibility since the computed t-value was 8.61 and 6.65, respectively which can be translated as p-value of less than 0.01 denoted a significant difference between the means of the two groups.

7) **Relationship on the Assessment Between Problem Solving Skills and Creative Thinking Skills of the Experimental Group**

The computed value of r for the over-all assessment of the students in the creative thinking skills and their problem-solving skills was equal to - 0.04 tells that there is a negligible negative relationship between the variables.

8) **Developed Teacher's Guide to Improve the Problem-Solving Skills and Creative Thinking Skills of the Students using Synectics Teaching Method**

The developed material by the researcher has a very satisfactory rating in terms of content and paper binding while in prints, illustrations and design, presentation and organization and accuracy and up-to datedness of information revealed a satisfactory rating from the experts. The physics selected topics were based from the least mastered competencies of students in Physics.

9. Conclusions

Based on the findings enumerated above, the following conclusions were drawn:

1) Synectic teaching model improves the problem-solving skills of the students in the eight (8) modules on lights and optics.
2) The post-test mean scores of the two groups in creative and thinking skills slightly differ with that of experimental group.
3) The students exposed to Synectics show better improvement in the problem-solving skills in the eight (8) modules compared to the traditional group.
4) Students exposed to Synectics teaching methods using the eight (8) modules in lights and optics performed better in their creative thinking skills compared to the traditional group.
5) The students exposed to Synectics teaching methods performed better in problem-solving skills than those who were not.
6) The creative thinking skills of students exposed to Synetics teachings method improved were significant than the students in the traditional group.
7) The problem-solving skills are not significantly associated with the creative thinking skills of the students exposed to Synectics.
8) The Instructional Module with Synectics Teaching in Physics is an effective tool in enhancing students' problem-solving skills and creative thinking skills.

10. Recommendations

From the foregoing conclusions, the following recommendations are hereby forwarded.

1) Teachers of Science, specifically in Physics, may utilize the synectically designed instructional materials in teaching identified difficult topics in science as it enhances the problem-solving skills and creative thinking skills of students.
2) School Administrators may encourage the use the instructional guide with synectics teaching method to

make the teaching-learning experience more meaningful and effective. They may provide trainings for teachers to achieve the goal of the school in the field of Science, Technology, Engineering and Mathematics (STEM) and other tracks with applied sciences.

3) Curriculum planners may incorporate the use of synectics teaching in different curriculum across learning areas. Mentoring can be extended to capacitate competencies and confidence level of science teachers who will work on synectics teaching method.
4) Parents may partner with their teachers to attain holistic development to become creative thinkers and problem solvers in all and across learning areas.
5) For future researchers, this study may be replicated in other subjects in the senior high school aside from Physics.

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