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Enhancing Pedagogy through Action Research: A Model-Building Strategy for Teaching the Structure of Carbon Atom using Recyclable Materials

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Abstract***: This study delves into the effectivity of using the modelling strategy in teaching the concept of the structure of carbon atom. The students were tasked to create a model of the structure of the carbon atom using recyclable materials as part of their project in science with the aims that by doing so, the students will develop better retention of the carbon structure and will help them in grasping the concept easily. The students were subjected to a pre-test and post-test as part of the assessment to evaluate the effectivity of the modelling strategy which then, was proven to be effective, given that the results of the post-test were significantly higher compared to their pre-test. The students were also able to reflect the usage of recyclable materials as part of the instruction in model-building as relative to its impact to environment.***

Keywords: modelling strategy, carbon structure, grasping concepts, recyclable materials

I.

I. INTRODUCTION

Modelling Strategy

The infinite pursuit of effective teaching and learning process has always been the center of academic discussions. According to United Nations (UN) Sustainable Development Goals (2015), Goal 4, which is about Quality Education, it is said that all children, primary, secondary and even tertiary, are entitled to quality teaching and learning regardless different varying reasons. With that in mind, teachers around the world have always been constantly improving their art of teaching to improve the quality of education. One of the subjects that students find difficulty in learning is Science. One of the reasons why students find science to be quite difficult is that complex abstract concepts, especially in Physics and Chemistry concepts where students are required to understand and apply complex theories and formulas (Sanchez, 2023). Another difficulty that teachers usually encounter when teaching science concepts is the ability of the students to understand and analyze models or structures. The students find it hard to learn chemistry concepts as there is little to no interaction, demonstration practice, lab exercise, or hands-on and hands-on experiments (Ali, 2012).

Teaching science concepts can be quite challenging at this day and age of technology where most students are categorized as visual learners. According to statistics, 65% of the population are visual learners (Zopt et. al., 2004) which is the reason why mostly of our educational learning materials are in video and audio formats as seen in different social media platforms, especially on YouTube with accounts like DepEd TV, which boasts a wide array of videos teaching lessons in each different grade levels. Nowadays, teachers are in constant search of different teaching strategies and techniques on how to teach students effectively while still managing to instill to them the concept of the lesson discussed.

One intervention that teachers use in classroom to teach chemistry concepts is the model-building strategy or the modelling strategy, where the teachers use models or representation of some lessons in chemistry to aid with the discussion. Modelling is a teaching strategy used by teachers to help the students grasp the concept clearly and easily through the process of observation and analysis. According to Albert Bandura's Social Learning Theory, pure behaviorism alone cannot explain why the learning process occurs in absence of external reinforcement. He emphasized that cognitive processes in learning is vital in increasing the learning process. The use of scientific models is to effectively describe, explain and scientific ideas clearly to other people (Oh & Oh (2011). The use of models in science, especially when teaching concepts like cycles, relationships and sequences, has become a greatly efficient and helpful. Students, with the help of models, can infer what the topic is all about and can help them explain the concepts cohesively.

Certain topics in science may be hard for students to visualize or develop any idea from. One of the topics where students have a hard time grasping is the topic about the Structure of the Carbon Atom – and how this affects the type of bonds it can form. Physical models can provide superior learning opportunities beyond the benefits of active engagements (Newman, et.al., 2018). This research explores the

effectivity of the use of Model-Building strategy in addressing the difficulty of students in grasping the topic of the structure of Carbon Atom and how, through this modelling strategy using recyclable materials, may have an impact on environmental science.

Carbon Structure

Studying the chemistry of carbon might be quite challenging for students given the different terminologies, different structure of compounds and the different rules of nomenclature present as well. Students have to retain and manipulate mental models to represent chemical reactions and they have to think about the molecular structure of the reactants (TESS Teacher Education through School-based Support -India, 2014). Carbon Atom and its structure is one of the topics in chemistry that students find difficult to learn due to the fact that there is not enough representation readily available for use to aid in the teaching of this topic. Public schools make use of self-made models in substitute of real models in order to facilitate learning while trying to achieve the same quality results of discussion.

Recyclable Materials

The use of recyclable materials in making models for instructional purposes has a significant impact on environment. Doing so, may lead to the integration of the so-called 'Environmental Education'. Environmental Education is defined as a discipline or process that educate individuals on behaviors and practices that safeguard resources for future generations while minimizing negative environmental impacts (Fang, et. al., 2023). In the Philippines, we have The National Environmental Education Action Plan (2018-2040), which outlines the environmental plan that we have for the succeeding years to come. In line with this, the government pushes for an incorporation of environmental promotion and awareness in school settings. The use of recyclable materials in making models of carbon atom structure, is only one step of embarking on environmental education towards sustainable development.

II. STATEMENT OF THE PROBLEM

This study aims to address these two problems encountered by teachers in teaching the concept of the Structure of Carbon Atom. (1) **The difficulty of students in grasping the structure of the Carbon Atom and how this affects the type of bonds it forms,** and (2) **The integration Environmental Science in teaching the structure of Carbon Atom through the use of recyclable materials.** This research aims to gather results that could potentially boost the students understanding of the topic presented and will be able to make a positive impact in the environment.

RESEARCH AIM AND OBJECTIVES

This research aims to evaluate the significant effect of the integration of modelling activity in teaching the concept of the structure of carbon atom using recyclable materials. Along with this aim, this research will move forward following these three (3) objectives:

1. To gather positive results from the integration of modelling activity in teaching the concept of the structure of carbon atom
2. To use recyclable materials in conducting the modelling activity to emphasize the impact of using these materials in alleviating waste and pollution in our environment.
3. To establish quality education while instilling the concept of sustainability in students through the integration of modelling activity using recyclable materials.

III. CONCEPTUAL FRAMEWORK

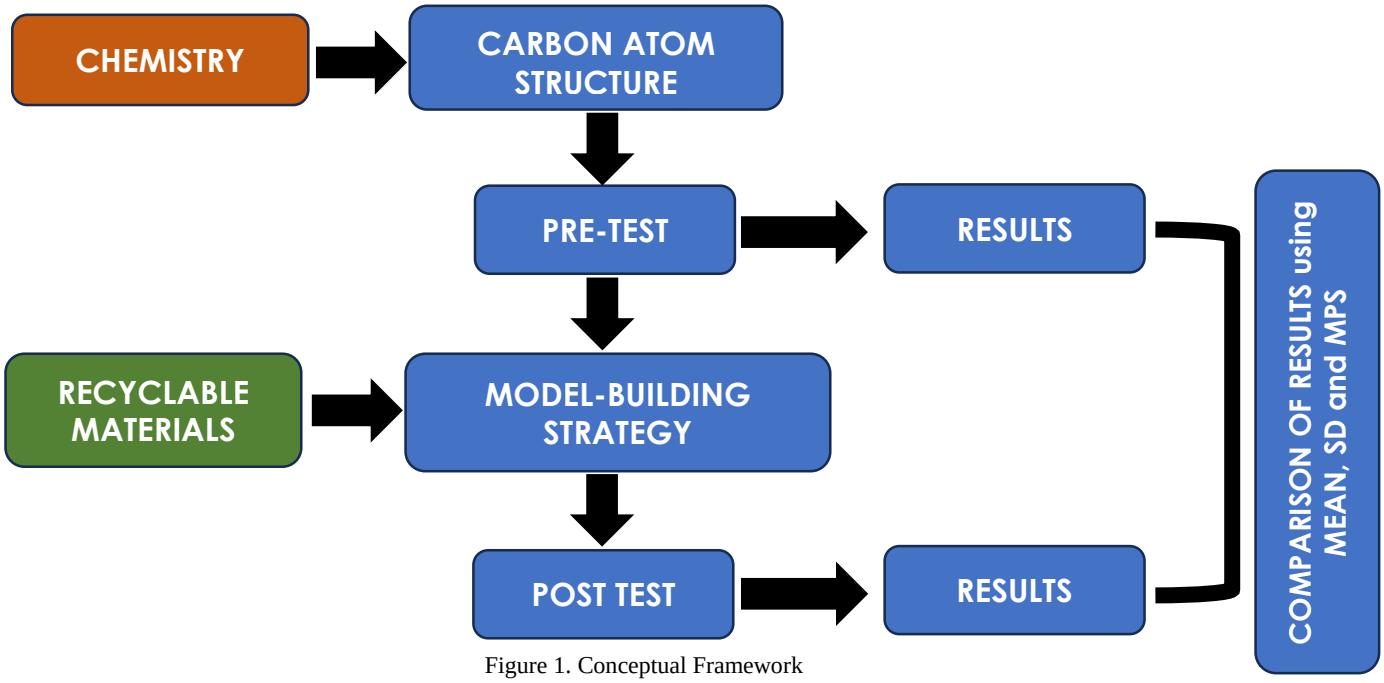

Figure 1. Conceptual Framework

METHODOLOGY

The study was conducted in Sangley Point National High School in Cavite City involving Grade 9 students on all six (6) sections: Algenib, Altair, Antares, Polaris, Spica and Vega having 30 students each section. The six (6) sections underwent a 20-item pre-test about the topic of Carbon Atom Structure before they made a model of carbon atom structure using recyclable materials and the discussion of the topic. At the end of the one-week lesson about Carbon Atom Structure using the model that the students built, the Grade 9 students will take their 20-item post-test which is designed to test whether the students will yield significant results in the post-test compared to their pre-test results. This study aims to show significant results from the post-test of the students when compared to their pre-test results, thus, proving that the model-building activity and using the model that they have built in classroom discussion is an effective strategy to make the students fully grasp the topic presented while realizing the impact of using recyclable materials in our environment and their role in helping to reduce pollution in our country.

RESEARCH INSTRUMENT

The study made use of a 20-item questionnaire test validated by 1 Master Teacher in Science and 2 Teachers in English which is narrowed down and selected from a pool of 50 questions regarding the carbon atom structure. The questions were then reproduced to be used as pre-test and were then shuffled to the made as post-test for the student participants in this study.

To facilitate the interpretation of the results for learners' assessment of their pre-test and post-test results, the following mean percentage scores with their corresponding interpretations were used:

Percentage Score	Verbal Interpretation
75% - 100%	High Mastery
54% - 74%	Moderate Mastery
0% - 49%	Low Mastery

STATISTICAL ANALYSIS

This study has a Quasi-Experimental Design with statistical analyses including Mean, Standard Deviation and Mean Percentage score is employed.

IV. RESULTS AND DISCUSSION

Results of this study was discussed under 4 major headings namely: Results of Pre-Test about the Carbon Atom Structure, Over-all results of Pre-Test for all six sections, Results of Post-Test about Carbon Atom Structure conducted after the modelling activity, Over-all results of Post-Test for all six sections.

Results of the 20-item Pre-Test about the Carbon Atom Structure

The results of the pre-test from all six sections of Grade 9 students are shown in this table along with the mean, standard deviation and mean percentage score per each section.

Table 1: Results of the 20-item Pre-Test about the Carbon Atom Structure

Section	Spica	Antares	Altair	Polaris	Vega	Algenib
Total of Raw Scores	266	314	326	391	267	377
No of Students	30	30	30	30	30	30
No of Items	20	20	20	20	20	20
Mean	8.87	10.47	10.87	13.03	8.90	12.57
SD	3.43	3.54	3.97	3.38	3.46	3.43
MPS	**44%**	**52%**	**54%**	**65%**	**45%**	**63%**

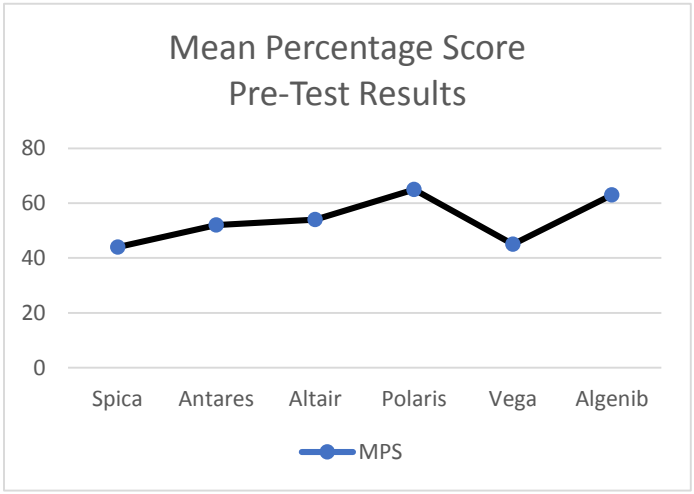

Figure 2. Mean Percentage Score (Pre-Test)

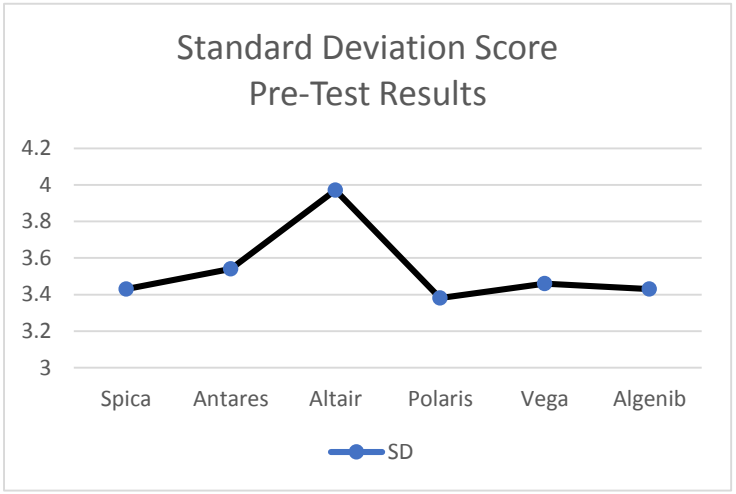

Figure 3. Standard Deviation (Pre-Test)

The pre-test consists of 20 items about the Carbon Atom Structure and this was done before the modelling activity where the students will create a model of Carbon Atom on their own. This table includes the necessary data about the result of the pre-test such as the total of raw score, which is the sum of all the scores of the students per each section with Section Polaris having the highest Total of Raw Scores of 391 and Section Spica having the lowest Total of Raw Scores having 266. This also shows the population of students having 30 students as sample size per each section. The Mean, Standard Deviation and Mean Percentage Score, which is included in the table are the numbers needed to be able to know if there is a significant change in post-test scores from their pre-test scores shown in the table above. Pertaining to the pre-test, Section Polaris has the highest Mean having 13.03 which is directly correlated with the Total of Raw Scores and MPS (65%) and Section Spica having the lowest Mean as 8.87 directly correlated with the Total of Raw Scores and MPS (44%). Standard Deviation is a measure of the amount of variation that is related to the mean which indicates that the higher the value of Standard Deviation, the greater the spread of scores. Section Altair has the highest SD having 3.97 and both Section Spica and Section Algenib, has the lowest SD with 3.43

Summary of the Results of Pre-Test of all Six Sections of Grade 9 Student

The cumulative results of the pre-test from all six sections of Grade 9 students are shown in this table along with the over-all mean, standard deviation and mean percentage score.

Table 2: Summary of the Results of Pre-Test of all Six Sections of Grade 9 Student

SUMMARY OF RESULTS	
Number of Learners Tested	180
Number of Tested Items	20
Total Score Obtained	1941
Mean	10.79
Standard Deviation (Raw Score)	4.09
Mean Percentage Score	53.95%

The table shows the over-all results of the Pre-Test conducted on all six sections of Grade 9 Students having included the over-all Total Number of Learners Tested which is 180 students; Total Number of Items which is 20 items; Total Score Obtained for all six sections being 1941; Total Mean for all six sections which is 10.79; Total Standard Deviation for all six sections which is 4.09 and the Total Mean Percentage Score for all six sections which is 53.95%

Results of the 20-item Post-Test about the Carbon Atom Structure

The results of the post-test from all six sections of Grade 9 students are shown in this table along with the mean, standard deviation and mean percentage score per each section.

Table 3: Results of the 20-item Post-Test about the Carbon Atom Structure

Section	Spica	Antares	Altair	Polaris	Vega	Algenib
Total of Raw Scores	499	457	461	514	433	522
No of Students	30	30	30	30	30	30
No of Items	20	20	20	20	20	20
Mean	16.63	15.23	15.37	17.13	14.43	17.40
SD	3.15	3.05	2.59	2.84	2.45	2.65
MPS	**83%**	**76%**	**77%**	**86%**	**72%**	**87%**

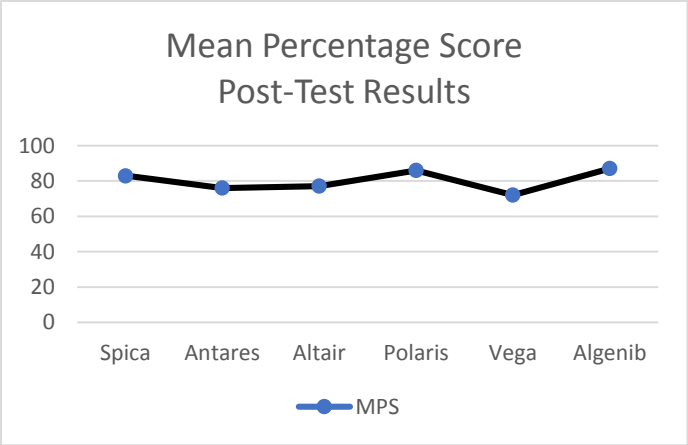

Figure 4. Mean Percentage Score (Post-Test)

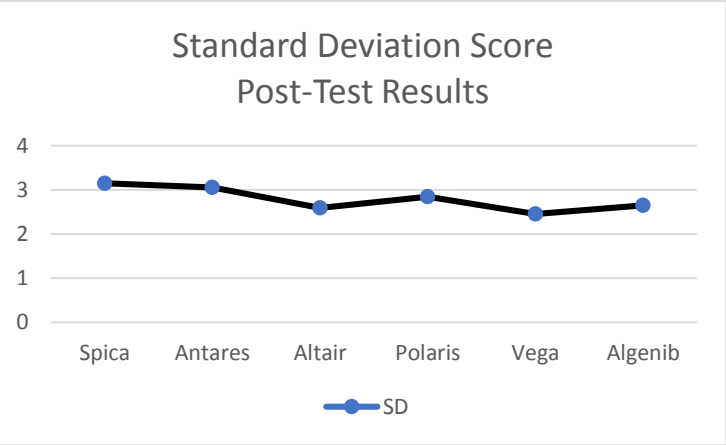

Figure 5. Standard Deviation (Post-Test)

The post-test, parallel to the pre-test, consists of 20 items about the Carbon Atom Structure and this was done after the modelling activity where the students created a model of Carbon Atom on their own. This table includes the necessary data about the result of the post-test such as the total of raw score, which is the sum of all the scores of the students per each section with Section Polaris still having the highest Total of Raw Scores of 514 compared to the pre-test result of 391 and Section Vega having the lowest Total of Raw Scores having 433 compared to their pre-test result of 267. There is also a significant change in the Total of Raw Scores for all six sections having all of them observed a notable increase. The Mean, Standard Deviation and Mean Percentage Score, which is included in the table are the numbers that shows that there is a significant change in post-test scores from their pre-test scores shown in the table above. Pertaining to the post-test, Section Algenib now has the highest Mean having 17.40, which is higher compared to the results of pre-test having 12.57, which is directly correlated with the Total of Raw Scores and MPS (87%) and Section Vega now having the lowest Mean as 14.43, which is still higher compared to the pre-test results of 8.90, directly correlated with the Total of Raw Scores and MPS (72%). All six sections showed notable increase in their Mean Scores for post-test compared to their Mean scores in pre-test. Standard Deviation is a measure of the amount of variation that is related to the mean which indicates that the higher the value of Standard Deviation, the greater the spread of scores. Section Spica has the highest SD having 3.15, which is lower compared to the pre-test results of 3.43 and Section Vega has the lowest SD having 2.45 which is lower compared to the pre-test results of 3.46.

Summary of the Results of Post-Test of all Six Sections of Grade 9 Students

The cumulative results of the post-test from all six sections of Grade 9 students are shown in this table along with the over-all mean, standard deviation and mean percentage score.

Table 4: Summary of the Results of Post-Test of all Six Sections of Grade 9 Students

SUMMARY OF RESULTS	
Number of Learners Tested	180
Number of Tested Items	20
Total Score Obtained	2886
Mean	16.03
Standard Deviation (Raw Score)	3.35
Mean Percentage Score	80.15%

The table shows the over-all results of the Post-Test conducted on all six sections of Grade 9 Students having included the over-all Total Number of Learners Tested which is 180 students; Total Number of Items which is 20 items; Total Score Obtained for all six sections being 2886 which is higher compared to the pre-test results of 1941; Total Mean for all six sections which is 16.03 which is higher compared to the pre-test results of 10.79, indicating an increase in the scores obtained by the students; Total Standard Deviation for all six sections which is 3.35 which is lower compared to the result of the pre-test of 4.09, indicating a decrease in the spread of scores of the students and the Total Mean Percentage Score for all six sections has gone up to 80.15% compared to the results of pre-test having an MPS of 53.95%.

CONCLUSION

The results of the post-test having significant increase than the results of the pre-test indicated a positive response to the modelling activity that was done by all the six sections of Grade 9 students in Sangley Point National High School, Cavite City. This proves that the difficulty of students in dealing with complex application of theories in chemistry topics (Sanchez, 2023) and the lack of hands-on experience (Ali, 2012) has been improved by the modelling activity that they have done before taking the post-test.

The modelling activity done by the students by creating a visual model using recyclable materials has been proven to be helpful in aiding with the discussion of the lesson in a more relatable sense, having the students see the actual model, knowing full well that 65% of learners are considered to be visual learners (Zopt et. al., 2004), the model that they have made has made the discussion easier to digest and clearly cascaded to the students (Oh & Oh (2011). Having physical models that students can see and manipulate has proven to be a great support beyond the benefits of active engagements (Newman, et.al., 2018).

The topic of Carbon Atom Structure has been found to be a difficult to understand and visualize by the students. They tend to make mental models in order to understand the topics such as this (TESS Teacher Education through School-based Support -India, 2014). Through this study, it is observed that having incorporated the modelling strategy in classroom instruction has proven to have a significant change, notably, an increase in the scores of the students in their post-test relevant to the topic of Carbon Atom Structure.

In line with the integration of the modelling strategy in classroom instruction, the inclusion of environmental education (Fang, et. al., 2023) has also been associated to this study as well, having the Carbon Atom Structure model been made using recyclable materials. The use of recyclable materials that are no longer functionable for its original use, has been the instructed materials to be used in the creation of this model. Having used recyclable materials is one step further in the full integration of environmental education. This study has proven that the modelling strategy used in dealing with the topic of Carbon Atom Structure using recyclable materials has been effective in improving the quality of teaching and learning process (UN-SDG, 2015), while incorporating efficiently environmental education.

ACKNOWLEDGMENT

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I am also grateful to my classmates and co-workers, for their feedbacks, advices, and moral support that helped a lot with this study. The validation and reliability of the research instrument that was used in the pre-test and post-test of this study was done by my reliable co-workers, to whom I am grateful. Lastly, my utmost thanks to my family and friends for being a solid foundation and support for me in achieving this feat.

And to the Almighty One, my heart is full of gratitude for the opportunity to be able to execute and make this action research.

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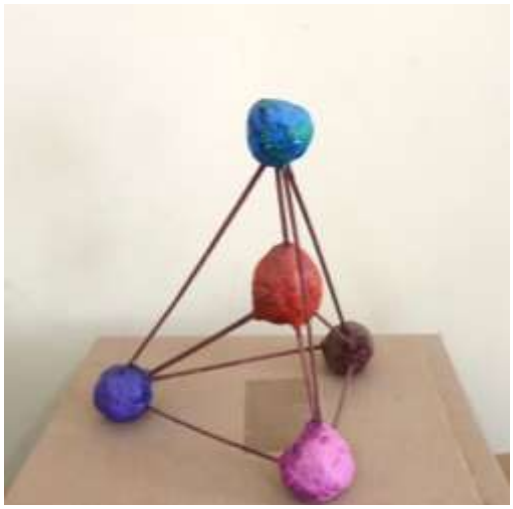
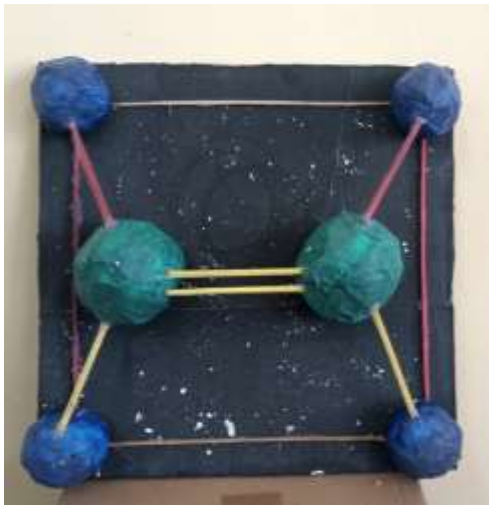
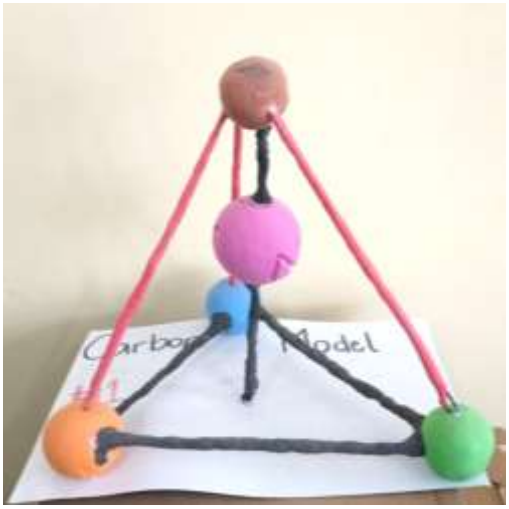
Appendix A

Pictures of some of the Carbon Atom Structure Model made by the Grade 9 Students







Appendix B

Pre-Test and Post Test Results of the Grade 9 Students about the topic of Carbon Atom Structure

Department of Education
Region IV-A CALABARZON
Division of Cavite City

Sangley Point National High School

AUTOMATED ITEM ANALYSIS - PRE TEST

SCIENCE 9

SY 2023-2024

Section	SPICA	ANTARES	ALTAIR	POLARIS	VEGA	ALGENIB
No.	SCORE	SCORE	SCORE	SCORE	SCORE	SCORE
2	5	10	7	19	6	10
3	11	11	14	15	5	13
4	14	10	17	9	5	15
5	13	6	8	17	4	12
6	12	8	8	16	7	18
7	7	17	17	11	13	18
8	5	7	14	12	8	13
9	5	7	18	15	11	12
10	2	16	11	14	6	15
11	6	14	8	12	9	13
12	7	14	11	14	7	17
13	9	11	14	15	16	10
14	11	11	13	14	14	11
15	13	14	19	13	14	16
16	11	9	11	10	7	13
17	8	10	13	14	10	17
18	8	7	10	7	14	15
19	6	13	8	15	7	15
20	8	10	8	14	6	11
21	12	7	7	7	6	9
22	6	16	11	7	10	9
23	16	15	8	17	6	8
24	12	7	7	15	12	13
25	9	4	7	7	7	15
26	10	8	6	12	8	10
27	10	11	4	15	8	14
28	3	6	11	8	4	5
29	13	11	8	15	14	5
30	7	8	17	15	10	15
TOTAL	**266**	**314**	**326**	**391**	**267**	**377**
NoS	**30**	**30**	**30**	**30**	**30**	**30**
NoI	**20**	**20**	**20**	**20**	**20**	**20**
Mean	**8.87**	**10.47**	**10.87**	**13.03**	**8.90**	**12.57**
SD	**3.43**	**3.54**	**3.97**	**3.38**	**3.46**	**3.43**
MPS	**44%**	**52%**	**54%**	**65%**	**45%**	**63%**

Department of Education
Region IV-A CALABARZON
Division of Cavite City

Sangley Point National High School

AUTOMATED ITEM ANALYSIS - POST TEST

SCIENCE 9

SY 2023-2024

Section	SPICA	ANTARES	ALTAIR	POLARIS	VEGA	ALGENIB
No.	SCORE	SCORE	SCORE	SCORE	SCORE	SCORE
1	13	17	13	20	14	20
2	15	16	16	20	17	16
3	13	17	16	20	13	15
4	20	17	13	16	12	15
5	12	18	20	15	18	18
6	14	15	14	13	15	16
7	19	11	11	20	12	15
8	20	13	16	13	16	20
9	17	19	11	20	13	17
10	19	10	13	14	13	20
11	16	14	12	18	18	20
12	20	20	19	15	15	19
13	13	15	16	18	14	15
14	18	11	12	20	12	16
15	12	10	15	15	13	19
16	20	19	17	14	14	17
17	18	17	11	19	12	15
18	9	16	16	9	15	20
19	15	16	18	18	16	15
20	19	13	18	19	17	20
21	13	13	16	16	19	20
22	20	16	15	19	11	10
23	19	12	18	17	14	20
24	20	18	16	16	12	17
25	17	14	13	15	17	20
26	16	10	15	16	11	20
27	20	14	17	19	12	13
28	17	20	17	20	15	15
29	15	17	20	20	13	20
30	20	19	17	20	20	19
TOTAL	**499**	**457**	**461**	**514**	**433**	**522**
NoS	**30**	**30**	**30**	**30**	**30**	**30**
NoI	**20**	**20**	**20**	**20**	**20**	**20**
Mean	**16.63**	**15.23**	**15.37**	**17.13**	**14.43**	**17.40**
SD	**3.15**	**3.05**	**2.59**	**2.84**	**2.45**	**2.65**
MPS	**83%**	**76%**	**77%**	**86%**	**72%**	**87%**