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Project-based learning approach on content mastery and cognitive skills: a pedagogical model for senior high school biology students

Abordagem de aprendizagem baseada em projetos sobre domínio de conteúdo e habilidades cognitivas: um modelo pedagógico para alunos de biologia do ensino médio

Enfoque de aprendizaje basado en proyectos sobre dominio de contenidos y habilidades cognitivas: un modelo pedagógico para estudiantes de biología de secundaria

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The article is original and profoundly novel since the present curriculum in science education in the Philippines is an inquiry-based approach, and it is still at the bottom of the recent PISA results. In this study, the Project-based Learning Approach would serve as an alternative option for education leaders in the country since a significant difference in the results is manifested. A pedagogical can be their source of guidance in the implementation of the Project-based Learning Approach.

ABSTRACT

The principal objective of this study was to determine the effectiveness of a project-based learning approach on the performance level and engagement experience of Senior High School Biology students. Quasi-experimental, specifically the One-Group-Pretest-Posttest Design was employed using mean percentage score and t-test as statistical tools in the treatment of data. The findings revealed that the mean percentage score of students across content areas and cognitive skills did not meet the expectations and were interpreted as being at the beginning level. Nevertheless, there is a significant difference between the pretest and posttest results covering content areas, namely: cells, biological molecules, and energy transformation. Likewise, a significant difference was revealed between the pretest and posttest scores throughout cognitive skills, such as comprehension, analysis, and application. The results suggest that the study can be very helpful to teachers of 21st-century learners so that they can have meaningful engagement in the class by exposing them to project tasks that develop their creativity, critical thinking skills, collaboration, ownership, and self-reflection. In addition, teachers should reinforce basic concepts, employ visual aids, foster active learning, stimulate critical thinking, and adopt an inquiry-based approach. They must also facilitate collaborative learning, ensure inclusivity, enhance project-based learning using models, cultivate metacognitive skills, and simplify complex concepts through scaffolding.

Keywords: education; project-based learning approach; senior high school biology students; pedagogical model.

RESUMO

O objetivo principal deste estudo foi determinar a eficácia da abordagem de aprendizagem baseada em projetos no nível de desempenho e experiência de envolvimento de alunos de Biologia do Ensino Médio. Quase-experimental, especificamente o Design One-Group-Pré-teste-Pós-teste foi empregado utilizando pontuação média percentual e teste t como ferramenta estatística no tratamento dos dados. Os resultados revelaram que a pontuação percentual média dos alunos nas áreas de conteúdo e habilidades cognitivas não atendeu às expectativas e foi interpretada como estando no nível inicial. No entanto, existe uma diferença significativa entre os resultados do pré-teste e do pós-teste abrangendo áreas de conteúdo, nomeadamente: células, moléculas biológicas e transformação de energia. Da mesma forma, foi revelada uma diferença significativa entre as pontuações do pré e pós-teste em todas as habilidades cognitivas, como compreensão, análise e aplicação. O resultado sugere que o estudo pode ser muito útil para professores de alunos do século 21, para que possam ter um envolvimento significativo na aula, expondo-os a tarefas de projeto que desenvolvam a sua criatividade, habilidades de pensamento crítico, colaboração, propriedade e autorreflexão. . Além disso, os professores devem reforçar conceitos básicos, utilizar recursos visuais, promover a aprendizagem ativa, estimular o pensamento crítico e adotar uma abordagem baseada na investigação. Devem também facilitar a aprendizagem colaborativa, garantir a inclusão, melhorar a aprendizagem baseada em projetos utilizando modelos, cultivar competências metacognitivas e simplificar conceitos complexos através de estratégias.

Palavras-chave: Educação; abordagem de aprendizagem baseada em projetos; estudantes de biologia do ensino médio; modelo pedagógico.

RESUMEN

El objetivo principal de este estudio fue determinar la efectividad del enfoque de aprendizaje basado en proyectos en el nivel de desempeño y la experiencia de participación de los estudiantes de Biología de la escuela secundaria superior. Se empleó un diseño cuasiexperimental, específicamente el diseño de prueba previa y posterior de un grupo, utilizando la puntuación porcentual media y la prueba t como herramienta estadística en el tratamiento de los datos. Los hallazgos revelaron que el puntaje porcentual medio de los estudiantes en todas las áreas de contenido y habilidades cognitivas no cumplió con las expectativas y se interpretó como si estuviera en el nivel inicial. Sin embargo, existe una diferencia significativa entre los resultados de la prueba previa y posterior que cubren áreas de contenido, a saber: células, moléculas biológicas y transformación de energía. Asimismo, se reveló una diferencia significativa entre las puntuaciones del pretest y postest en todas las habilidades cognitivas, como comprensión, análisis y aplicación. El resultado sugiere que el estudio puede ser muy útil para los profesores de estudiantes del siglo XXI para que puedan tener una participación significativa en la clase al exponerlos a tareas de proyectos que desarrollen su creatividad, habilidades de pensamiento crítico, colaboración, propiedad y autorreflexión. . Además, los profesores deben reforzar los conceptos básicos, emplear ayudas visuales, fomentar el aprendizaje activo, estimular el pensamiento crítico y adoptar un enfoque basado en la investigación. También deben facilitar el aprendizaje colaborativo, garantizar la inclusión, mejorar el aprendizaje basado en proyectos utilizando modelos, cultivar habilidades metacognitivas y simplificar conceptos complejos mediante escalas.

Palabras clave: educación; enfoque de aprendizaje basado en proyectos; estudiantes de biología de secundaria; modelo pedagógico.

INTRODUCTION

Science can be a highly fascinating subject since it enables us to comprehend the world around us. Unfortunately, many students in many parts of world have poor performance of it. Ineffective methodology in science education, students who have negative attitude toward the subjects, Unfortunate family environment and background as well as insufficiency of physical facilities and instructional materials (Oduol, 2018). The 2019 iteration of the Trends in International Mathematics and Science Study (TIMSS) divulged that the average score of Filipino students was 249. This score was notably the lowest among the 58 participating nations, with the overall average score approximated at 491. The data further suggests that a mere 19% of Filipino students were able to achieve scores at or above the established Low benchmark. This implies that a substantial majority of Filipino students exhibited a deficient comprehension of scientific concepts, coupled with a rudimentary understanding of fundamental facts pertaining to science.

In the Philippines, the Program International Student Assessment (PISA) 2018 shows that the country got significantly lower score in scientific literacy compare to other countries in ASEAN. The average Scientific Literacy score for Filipino pupils was 357 points (Proficiency Level 1a), which is much lower than the OECD average (489 points or Proficiency Level 3). Likewise, the National Achievement Test (NAT) 2018 revealed that the mean score for STEM subjects (Mathematics and Science) are declining into 80% at low or zero proficiency. This implies that Filipino students have poor performance in Mathematics and Science.

Numerous elements contribute to the poor performance of students in science subjects. Socio-economic adversities place children in a disadvantaged position, which has been linked to the underachievement of such students in science and mathematics (Banerjee, 2016). This finding is corroborated by Kilic Depren (2020), who posits that economic and social status, along with the availability of information communication technology, are significant factors influencing students' achievements in science. In the context of a General Biology class, Lebata and Mudau (2014) identify potential influencers of student performance to include the learners themselves, teachers, parents, management, financial support, availability of well-equipped libraries and laboratories, access to Biology textbooks, and teaching methodologies.

Moreover, in the local setting, as recorded by a planning officer that the average Learner's Progress and Achievement of Junior High School students in science in Santa Cruz National High School S.Y. 2021-2022 is 83. 85% which is interpreted as Satisfactory. Likewise, the Senior High School students who took the General Biology 1 in recent semester S.Y. 2022-2023 got the average of 86.5% which is interpreted as Very Satisfactory. This only means that only few students got the Outstanding ratings of (90-100) and a lot of students fall below the average that they got. Further, as observed by the Master Teacher in Santa Cruz National High School, during a closer interview that students now a days have lacked the fundamental skills that a 21st century learners must possess which are the teamwork, problem solving, research gathering, time management, information synthesizing and utilizing of high-tech tools. He added that the engagement of students is not effective when you are just using conventional way of teaching. Also, the engagement of students can be more fun and meaningful when students involved in something they can experience or manipulate like having experimentation or making collaborative projects.

The researcher would like to investigate whether these existing problems above- mentioned can be alleviated using Project-based learning approach as treatment or intervention. Project-based learning approach (PBL) reports positive outcomes related to students learning in science. PBL has several positive effects on student's content knowledge compared to traditional teaching method. Students in PBL approach performed better on assessment of science content knowledge. Students who participated in PBL, also benefitted from improved critical thinking and Problem-solving skill. PBL has been show to benefit a variety of students in developing collaborative skill. In summary, present study indicates that PBL approach has appositive effect on student content knowledge of science and the development of skills such as collaboration, critical thinking and problem-solving abilities in real life situation (Gangwar, 2017).

In addition, research study from Hugerat (2016) found out that teaching science by the project-based learning method significantly improved student teacher relationships, and enhanced student's enjoyment. These variables led to the creation of a positive educational climate that enabled the teacher to achieve the lessons objectives and the students to benet. Further, new standards in science education are being advocated that react the current vision of content, pedagogy, student's assessment of the classroom environment, and the support necessary to provide a high-quality education for all students.

The researcher has not come across of a study that dealt on project-based approach on the performance level and engagement of students. Hence, this study fills the gap in the debate of whether project-based approach can have an effect the performance level in content mastery and cognitive skills and engagement of students. The findings of this study contribute to the body of literature expanding the concept of project-based approach in the realm of education.

Statement of the Problem

The study aims to determine the effectiveness of project-based learning approach on the performance Level in content mastery and cognitive skills of Senior High School biology students.

Specifically, it will answer the following questions:

1. What is the performance level of the General Biology students in the pretest and posttest in the following content areas: i) Cell;ii) Biological Molecules; and, iii) Energy Transformation?

2. What is the performance level of the General Biology students in the pretest and posttest in the following cognitive skills: i) Comprehension; ii) Application; and, iii) Analysis?

3. What lesson exemplar could be design?

4. Is there a significant difference in the following: i) Pretest and posttest in the performance level in Content Mastery?; ii) Pretest and posttest in the performance level in Cognitive Skills?

5. Based on the findings, what pedagogical model could be design for the contextualization of Project-based Learning Approach?

Theoretical Foundation

This research study was anchored on the proposition of Chauang (2021) on applying constructivist learning theory and social learning theory. In constructivist learning theory, the learners are involved in a task in which they will construct knowledge out of their personal experiences, and the role of the teacher is to guide the students. Social Learning theory, on the other hand, hold that student learns best when their teacher serves as the positive role model. Further, learners tend to learn when they are able to draw experiences of those around them. Moreover, these two profound theoretical foundations can be elaborated in the theory of social constructivism, as emphasized in the research study of Amineh & Asl (2015), which expands on constructivism learning theory by highlighting the importance of social interaction and collaboration in learning. The project-based learning approach promotes social contact and collaboration among students as they collaborate to identify problems, brainstorm ideas, and develop solutions. Students can utilize each other's talents, share knowledge and expertise, and learn from one another through collaborative projects.

METHODOLOGY

This section outlines the study's design that the researcher will employ. These include the respondents of the study, the instrument of the study, the data gathering procedure, data analysis, and interpretation.

Research Design

The researcher employed quasi-experimental, specifically the one-group-pretest-posttest design, which is primarily quantitative. This design tests the participants outside the laboratory to determine the causal consequences. On the other hand, the nature of the experiment is different from an actual experiment in the laboratory, for it requires randomization of treatment. In quasi-experiments, assignment is determined by self-selection or administrator discretion (Cook, 2015).

In this research, only one group will be administered a pretest prior to treatment. Next, treatment will be given using the Project-based Learning Approach lesson exemplar. Finally, after the implementation of treatment, the students of the same group will be given a posttest to determine the causal consequences of the treatment. In addition, the researcher considered some measures of threats to validity. Due to the nature of its design, the study faced certain constraints. The methods do not promote or emphasize randomization in a wide range since it is a controlled experiment, which may prevent a more conclusive interpretation of the results.

Selection of Respondents

The quantitative aspect of the study involved a complete enumeration selection of Grade 12 Senior High School students from Southern Mindanao, Philippines.

Table 1. Respondents of the study

Name of School	Grade Level	Population (N)
School A	12	98
Total		**98**

Source: own elaboration with the research data (2024)

Table 1 showed the respondent of the study. The grade 12 student in Southern Mindanao, Philippines has a total population of 98. It comprises two sections from a STEM strand. The researcher employed "Census Method", which is referred to the complete enumeration or inclusion of a universe as respondents. A census is an initiative to enumerate every component within a group and quantify one or more of those components' attributes. It can offer thorough information on all or most elements in a population, allowing totals for rare population groupings or limited geographic regions (Britannica, 2024). In this research, all Grade 12 students in two sections of the STEM strand are enumerated as respondents of the study. They are the subject of the research and capable of answering the test questionnaire and interview questions.

Research Instruments

The researcher developed an achievement test in the form of a Multiple-Choice Test with a Table of Specifications, which was validated by three experts: two (2) Master Teachers teaching science education in the field and one (1) College Professor teaching Biology and Chemistry. The test questions were aligned to the content area of General Biology 1 from the Most Essential Learning Competencies (MELC) provided by the Department of Education. The development of 106 items multiple choice test also considered the different cognitive skills namely: comprehension, application and analysis. In order to identify the performance level being measured and guaranteed, an equally representative sample of questions to be included in the test items from each learning competency, and cognitive skills are specified using the One-Way Table of Specifications. Also, the TOS helped the researcher construct a test in it by determining which topics should be included or excluded. This makes it possible for the researcher to carefully consider and decide which particular topics are pertinent or appropriate for the examinees. The test items should comprise 106 items to ensure that there were still acceptable items to be retrieved after the item analysis for some items that were rejected and cannot be used.

In addition, the first set of 106 test questions underwent a validation process with the TOS itself to quickly identify the parallelism of the questions and whether those questions were aligned with learning competencies and corresponding cognitive skills. It was validated and checked by three validators who are experts in teaching science education specializing in biology. The validators gave their comment and suggestions for the improvement of the questions and gave a mean rating of 4.73, which was interpreted as very high in extent. Hence, in order to improve the test, the researcher has rewritten the test questions following the corrections, suggestions, and recommendations.

Furthermore, to assure that the construction of instrument is highly reliable and valid. The researcher conducted pilot testing by giving validated exams to students who were not included in the study; these are students who had already taken the General Biology 1 subject from other schools and divisions. The researcher underwent first and second trial run. The first trial run involves 56 students not included in the scope of study. Performed item analysis on 106 test items in order find out the difficulty index. The purpose of this pilot testing is to determine the test's level of validity and reliability. The index of difficulty, which offers each question a hard or easy rating, helps one to judge the veracity of the exam questions. The range of a possible score is 0.3 to 0.7. As a result, a score of less than 0.3 indicates that an item is too difficult, whereas a score of more than 0.7 indicates that an item is too simple.

In getting the frequency of correct and wrong items, the researcher marked each number of items with check (/) for the correct and ex (x) for the wrong answer. Next, the tally table was made, as well as the frequencies of each item. Each test taker receives a total of one hundred fifty points or marks for their performance. However, for the 150 items, the item difficulty and discriminating indices were calculated to select 75-80 items. The item analysis employed the 27% upper and 27% in the lower groups. Items with difficulty indices between 0.30 and 0.70 were chosen to be part of the final test, while those with indices below 0.30 and above 0.70 were disqualified for being either too difficult or too easy. The item discrimination index (D), which ranged from 0.30 to 0.44, served as the standard for accepting item-related discrimination indices for the final test. Furthermore, the result revealed in the difficulty indices that there were eight Very Easy items, 39 Easy items, 31 Moderately Difficult items, 21 Difficult items, and seven Very Difficult items. For the discrimination index, 49 were considered Discriminating, 35 were Moderately Discriminating, and 22 were Not Discriminating. In the overall scale, 49 items were Accepted, 39 Needs Revision, 18 were Discarded, and 15 were Improbable.

Moreover, in the second trial run reliability and internal consistency of the test items were established. Throughout the item analysis, items with unacceptable results for difficulty and discriminating indices were either retouched or removed. Finally, 50 items will remain for the second pilot testing or trial run. The Kuder-Richardson formula 20 will be used to assess the test's internal consistency (KR20). The test administered to students who were randomly selected from the general community with the intention of determining reliability. A KR-20 value of 0.73 was obtained indicating that the test could be used for research purposes ensuring internal consistency. In determining the internal consistency of the items, an acceptable level of 0.07 and above is needed. The result showed a highly reliable number of items, indicating acceptable internal consistency. The said test is comprising of 50 questions that focused on the target learning competencies and should base on K to 12 Senior High School curriculum.

Furthermore, the researcher made a lesson exemplar covering all the competencies of General Biology 1 across

content areas: Cell, Biological Molecules, and Energy Transformation. It adds to the existing performance standard the DepEd gave, as reflected in the curriculum guide. Six lesson exemplars address the urgency of project tasks throughout content areas and learning competencies. Before the Lesson exemplars undergo the validation process, they must be submitted by the research adviser for further scrutiny and suggestions. After that, each lesson exemplar was subjected to the validation process. It was validated by three experts: two (2) Master Teachers, who are experts in teaching science education, and one (1) College Professor, an expert in teaching biology and chemistry. The validators made comments and suggestions for the improvement of the lesson exemplar. The researcher revised the Lesson exemplars to match the comments and suggestions of the validators. Finally, the researcher administered the lesson Exemplar with the help of the adviser and the subject teacher for General Biology 1 subject.

Data Gathering Procedure

The following steps served as guidelines in gathering the data for this study:

Asking permission to conduct the study. A formal letter will be sent address to the Regional Director of DepEd XI to ask permission for the conduct of the study and to seek for his approval. As soon as the letter has granted, it will be distributed down to the School Division Superintendent as well as to the school principal of Santa Cruz National High School for the protocol of implementation.

Additionally, when administering the test questionnaire, the respondents answered it twice. The pre-test will be administered before the treatment to diagnose prior knowledge of the topics and give initial equivalents among groups. Nevertheless, a post-test was conducted to test the effect of the treatment. Preparation and Administration of Pre-test. The researcher prepared the test questionnaire that has to be administered to the respondents. The test will be based on the learning competency of the K -12 Curriculum for Grade 12 focusing on General Biology-first semester. According to the method outlined in the sampling design and methodology, students would only have one group for pretest and posttest. The students will be given a pretest assessment in the presence of the class adviser after everything has been set. Data will be obtained, collated, and tabulated to obtain the pretest results.

Preparation and Implementation of the Project-based Learning Approach. Before the conduct of the study begins, the project-based learning approach has to be extensively prepared and organized. The Science Master Teacher designated in each of the schools where the analysis will be performed will review the lesson exemplar. Science Teachers in General Biology of the schools included in the study will be brief and oriented about PBL Approach. The researcher will present the purpose of the study, test questionnaire and the lesson exemplar for the smooth conduct of the study. When all is set, the experimental group will be exposed to PBL following the competencies to be mastered in General Biology.

Administration of Post-test. The same test has to be given during the pre-test and it will be administered to the same group (experimental groups) after the administration of PBL approach. Data will be collected, gathered, and calculated in order to determine the posttest results.

Data Analysis

The mean for each area was computed and interpreted. As shown in box 2, the criteria for the interpretation of the mean following the scale given by the Department of Education as per mandate in DepEd Order No. 73, s. 2012, dated September 05, 2012.

The researcher employed mean and standard deviation for the items requiring descriptive statistics. T-test was used to determine the significant difference between the Project-based Learning Approach on the performance level in content mastery and cognitive skills of general biology students in both the pretest and post-test for the experimental groups. Further, Focus Group Discussion (FGD) was used to substantiate the engagement experiences of students on the treatment implemented, which is the Project-based Learning Approach. Table 2 shows the level of proficiency after summing up of the performance of grade 12 General Biology.

Table 2. Criteria for interpreting the mean performance of students

Level of Proficiency	Equivalent Numerical Value
Beginning	74% and below
Developing	75-79%
Approaching Proficiency	80-84%
Proficient	85-89%
Advanced	90% and above

Source: own elaboration with the research data (2024)

Ethical Considerations

There are significant ethical challenges and concerns that have unique consequences for this quantitative investigation. The challenges and concerns that may occur are mostly due to the methods employed in this study. The ethical considerations relevant to this research pertain to the matters of inform consent, voluntary participation, confidentiality of information and communication of results.

Informed assent/consent: The Grade 12 STEM students of the school were given an informed assent letter (17 and below) and consent letter (18 and above) to be signed with their parents. In that way parents may know what he's students are doing and can give advice whether he will allow his student or not.

Voluntary participations: The Grade 12 STEM students of the school were given the free will to participate without any form of consequence or, penalty or loss of benefits. Therefore, the purpose and the benefits of the study were described and presented to the participating school. Then, the rights of the respondents to contribute to the body of knowledge will be carefully considered and adhered to.

Privacy and confidentiality: The researcher kept private and with utmost confidentiality the respondents' personal information that may be required in the study. The names of students were not written in the answer sheets. Instead, the researcher gave codes so that their names were not exposed. Further, the recorded verbatim should not be heard from others and should be deleted after the data has been transcribed.

Communication of Results: The researcher highlights the significance of communicating research findings in a transparent manner. He may clarify that the results would be presented in an unbiased and truthful manner, free from any kind of manipulation or deception. Also, he may stress how important it is to share study results honestly and properly, without exaggerations or false conclusions. Recognize any limitation or uncertainties in the data and talk about how they were dealt with during the reporting process.

RESULTS

This section presented the findings on the effectiveness of the project-based learning approach. The tables were arranged to present the following findings: mean percentage scores of the pretest and posttest of the performance level of students in content mastery and cognitive skills, lesson exemplar, significant difference in the pretest and posttest across content areas and cognitive skills.

As shown in Table 3, the performance level of General Biology students in the pretest and posttest across content areas is presented. This relates to the first problem of the study.

Table 3. Performance level of General Biology students in the pretest and posttest across content areas

Content Areas	Mean Percentage Score			
	Pretest	Interpretation	Posttest	Interpretation
Cell	53.57	Beginning	73.08	Beginning
Biological Molecules	47.96	Beginning	69.18	Beginning
Energy Transformation	39.69	Beginning	58.92	Beginning
Over-all Mean	47.73	Beginning	67.31	Beginning

Source: own elaboration with the research data (2024)

It was reflected on the Table 3 that the overall mean percentage score in the pretest of content areas is 47.73 % and for the posttest is 67.31%. For the pretest, it can be gleaned in the table that their mean rating ranges from 39.69% to 53.57%. *Energy transformation* gained the lowest mean rating of 39.69% and *cell* gained the highest mean rating of 53.57%. On the other hand, it can be found in that the posttest's over all mean is 67.31%. *Energy transformation* obtained the lowest mean rating of 58. 92% and *cell* obtained the highest mean rating of 73.08%.

Performance level of General Biology students in the pretest and posttest across cognitive skills is presented in Table 4. This answers the second questions of the study.

Table 4. Performance level of the General Biology students in the pretest and posttest across cognitive skills

Cognitive Skills	Mean Percentage Score			
	Pretest	Interpretation	Posttest	Interpretation
Comprehension	47.53	Beginning	67.72	Beginning
Analysis	43.59	Beginning	63.85	Beginning
Application	55.10	Beginning	68.98	Beginning
Over-all Mean	47.73	Beginning	67.31	Beginning

Source: own elaboration with the research data (2024)

The overall mean percentage score in the pretest of cognitive skills ranged from 43.59% to 55.10% and the posttest ranged from 63.85% to 68. 98% respectively. In the pretest, the indicator that gained the lowest mean rating of 43.59% is the *analysis* and *application* gained the highest mean rating of 68.98%. On the flip side, the table provide insight that the posttest's mean score is 67.31% and the one that gained the lowest rating of 63.85% is *analysis* and gained the highest rating of 68.98 is the *application*.

Lesson Exemplar: the researcher developed a lesson exemplar with six (6) separate designated topics. Each lesson exemplar is composed of several parts. Part I consists of the objectives, which are subdivided into performance standards, content standards, learning competencies, and learning objectives. Part II is simply the content or topic. Part III is the Procedures. In the procedure, the researcher adopted the 7E's model, namely Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend.

Shown in the Table 5, the summary table for the test for significant difference in the pretest and posttest for content mastery is presented. It answers the question 4.1.

Table 5. Summary Table for the test for significant difference in the pretest and posttest for content mastery

Content Mastery	t-stat	df	p	Mean difference	SE difference
Cell	-10.85	97.0	<.000	-7.673	0.70
Biological Molecules	-6.86	97.0	<.000	-1.06	0.155
Energy Transformation	-9.99	97.0	<.000	-3.65	0.366
Overall	-12.20	97.0	<.000	-9.79	0.802

Source: own elaboration with the research data (2024)

The overall performance level of General Biology students in the pretest and posttest in content mastery, when computed and analyzed by t-tests, revealed a t-stat of -12.20 and p-value of 0.000, which is less than 0.005 level of significance. The content areas *cell*, *biological molecules* and *energy transformation* each had a t-stat of -10.85, -6.86, -9.99 respectively, and p-value of .000 throughout all the components.

Presented in Table 6 is the significant difference in the pretest and posttest for cognitive skills when analyzed and computed using t-test, which answers to the questions 4.2.

Table 6. Summary Table for the test for significant difference in the pretest and posttest for cognitive skills

Cognitive Skills	t-stat	df	p	Mean difference	SE difference
Comprehension	-10.85	97.0	<0.000	-7.673	0.707
Analysis	-8.04	97.0	<0.000	-1.418	0.176
Application	-4.22	97.0	<0.000	-0.694	0.164
Overall	-12.20	97.0	<0.000	-9.786	0.802

Source: own elaboration with the research data (2024)

The figures in Table 6 reveals that the overall t-stat is -12.20, and the p-value is 0.000, which is less than the 0.05 level of significance. The indicators comprehension, analysis, and application show t-stats of -10.85, -8.04, and -4.22 respectively, with p-values of 0.000 across components.

DISCUSSION

This section presents the analysis and interpretation of data, lesson exemplar, pedagogical model, conclusion and recommendation. The findings reveal that the Senior High School Biology students obtained low mean percentage score in the pretest and the posttest across the content areas, namely Cell, Biological Molecules, and Energy Transformation. Both results are interpreted as being at the beginning level, which means that the students did not meet the passing score expected by DepEd. Also, this implies that students have poor performance levels in the following content areas in General Biology 1 due to difficulty taking up the subjects, especially in the content areas of Energy Transformation, which gained the lowest mean percentage in the pretest and posttest, as a result of difficulty grasping the lesson due its complicated processes as the nature of the topic.

The results of the study are supported and has similarities with the research study of Bernardo et al. (2023) as they unearth the results of PISA 2018 that the performance for Filipino students for global assessments has always been significantly low in performance of science. This means that the average of Filipino learners in scientific literacy ranked second to last among 78 countries.

Likewise, in the Program for International Student Assessment (PISA) 2022, the Philippines landed 3rd at the bottom for the second time in comprehension, mathematics, and science out of 81 countries participated. Based on the reports, the Philippines scored less than the average in its 2022 assessment with 120 points, where 355 for math, 347 for reading and 373 for science. Nevertheless, indicators of the test revealed that despite its movement in the rank, the performance of students still in the minimal improvement. Hence, as an overall Mathematics has increased in 2.2 percent from 2018 to 2022, 6.9 percent in reading but a 0.8 drop in science proficiency. Similarly, the result of National Achievement Test (NAT) 2018 back up the reverberation of PISA 2018 and 2022 that says Science, Technology, Engineering, and Mathematics (STEM) subjects has declined to 80 percent and regard as zero proficiency.

Still, the research study conducted by Manzanares & Linaugo (2022) at their place of employment revealed that the results of the Quarterly Assessments from school years 2017-2018 to 2019-2020 showed low proficiency levels in science, particularly in Biology, with scores of 69.34 and 72.60, respectively. Hence, as the findings of the study implies that most of the Most Essential Learning Competencies (MELC) were least learned by the learners and regard as in the beginning level of proficiency in biology.

The findings are in contrast to the study of Larrier et al. (2016) that the project-based learning approach as an intervention is a student-centered pedagogical orientation where the educator acts as a facilitator, directing students in a collaborative, hands-on, active-learning session geared to build their competences and academic abilities. These entails several types of active inquiry learning approaches, such as PBL, which are critical to improving educational outcomes (De Witte and Rogge, 2016).

In addition, educators must revisit fundamental concepts of a certain topics because student got difficulty engaging the lessons if they have gap already on the topics that they don't know. Further, most of the Biology such as cell biology, biomolecules and some processes in energy transformation are difficult to comprehend without visual presentation. In so doing, teachers must integrate diagram, models and charts as visual aid to easily comprehend abstract concepts. Also, teachers must involve the students into active learning methods in which they may expose to interactive simulations, educational videos and hand on activities. The results exhibit a low mean percentage score in the performance level of Senior High School Biology students in the pretest and posttest throughout cognitive skills: Comprehension, Analysis, and Application. The result is interpreted as in the beginning level and did not meet the passing rating of the Department of Education. This is due to student's difficulties in analyzing the concepts.

The poor outcome in the performance level across cognitive skills aligns with the research conducted by Bernardo et al. (2023), which found that Filipino students' performance on PISA 2018 is complemented by another international assessment, the Trends in International Mathematics and Science Study (TIMSS). This assessment measures students' ability to apply their knowledge in various content areas in science. The performance was tested using benchmarks, each with a corresponding scale score: low (400), intermediate (475), high (550), and advanced (625). It was revealed that Filipino students in the TIMSS 2019 cycle had an average scale score of 249, the lowest among 58 participating countries, with an overall average score of roughly 491. This implies that only 19% of Filipino students obtained scores in the Low benchmark or higher, implying that the overwhelming majority of Filipino students "show limited understanding of scientific concepts and limited knowledge of foundational science facts" (Mullis et al., 2020).

The outcome is in line with the perspective of Paidi et al. (2020) on their research studies in Indonesia that the cognitive processes and knowledge of Senior High Biology students are not satisfactory. Further, the findings revealed that students who learned using Curriculum 2013 performed better on higher-order thinking skills (HOTS), procedural knowledge, and metacognitive knowledge than those who learned using curriculum in the past. Hence, it suggests that the learning of biology through innovative teaching approaches were recommended and deemed more successful in assisting students in better mastering cognitive processes and knowledge.

Moreover, a person who is capable of fulfilling significant learning has greater complexity of knowledge networks in their cognitive structure, which facilitates easier recall as a result of an increase in the conceptual links (Ozarslan & Çetin, 2018). Subsequently, educators should encourage critical thinking skills by giving them the opportunities to evaluate, analyze and solve problems. Students must be engaged into a project-based activity that requires them to think critically by making association of various concepts. Also, teacher must incorporate Inquiry-based approach in the form of practice questions in which students engage in practice tests or questions pertaining to each topic, with the aim of comprehending the reason behind the correctness or incorrectness of each response.

Besides, a lesson exemplar was developed as a treatment of the study. The six (6) lesson exemplars consist of distinct topics separately with corresponding project tasks. Each lesson exemplar has one to two performance standards as the basis for crafting the project. It is based on the performance standard of the Curriculum Guide of the Department of Education. However, not all topics and competencies were given equivalent project tasks in the performance standard. That is why the researcher created an additional performance standard for each exemplar and developed a new lesson exemplar for a new performance standard.

The lesson exemplar is divided into three parts. Part 1 consists of performance standards, content standards, learning competencies, and learning objectives. For the performance standard, the researcher utilized the existing performance standard of the curriculum guide of the Department of Education. He cannot change the performance standard because it is fixed and irrevocable, but the researcher can add to it. For certain competencies that cannot be covered by the performance standard in the curriculum guide of the Department of Education, it is time to add performance standards appropriate for certain competencies. A content standard consists of a certain main topic anchored on the curriculum guide. Learning competencies are fundamental competencies held together in the curriculum that are to be followed by the subject teacher and a basis for learning objectives. Finally, Learning Objectives are specific objectives made based on the learning competencies. It should contextualize the current status of the students in terms of their learning styles and capabilities.

Part II is simply the Content or the specific topic extracted from the content standard. Sub-topics will be made in this section in order to break down the complex topics from the content standard. Hence, students can easily digest the topic and promote engagement to the students.

Part III is the lesson proper. It adopted the 7E's model, which is the following: elicit, engage, explore, explain, elaborate, evaluate, and explain. In the elicit phase, it is the first step in which teachers examine students' previous knowledge and understanding of the subject matter. Questions, conversations, or activities may accomplish this. Engage phase seeks to awaken students' curiosity and interest in the subject matter. Teachers engage students in activities, questions, and demonstrations to activate their previous knowledge of the subject matter of the lesson. They are making learners curious and open to learning. In the exploration phase, students engage in hands-on learning, making observations and formulating theories. Teachers facilitate this by providing guidance and resources while promoting independent group work. In the explanation phase, the teacher offers explanations and direct instruction to help students grasp essential concepts after their investigation. Multimedia presentations, conversations, and demonstrations are used to effectively transmit the content and ensure a thorough understanding of the topic. Elaborate phase, students apply their new knowledge in different contexts through projects or problem-solving exercises, promoting deeper understanding by connecting lesson content to real-life situations. In the evaluation phase, educators assess students' mastery of course objectives through methods like tests and presentations, providing feedback to reinforce learning and identify potential areas for improvement. In the extend stage, students explore the subject further on their own or in groups. Teachers provide extension activities, tools, or research projects to foster curiosity and self-directed learning. This stage promotes a lifelong passion for knowledge.

The results display a significant difference between the pretest and posttest among content areas in General Biology 1, namely Cell, Biological Molecules, and Energy Transformation. After the administration of project-based learning, scores significantly increase, and a performance improvement is noticed due to its effectiveness.

The findings agreed to the assertion Kreutz (2019) that project-based learning approach as an intervention can accelerates the academic performance achievement of learners as it boosts their motivation and engagement in the class. Further, this research is beneficial for educators who are struggling with their student's poor engagement and academic achievement in the class due to boring teacher-centered instructions.

Moreover, PBL is reportedly to have a positive outcome in relation to student learning in science. As compared to traditional methods of teaching, PBL has numerous positive effects to content knowledge. Further, a student performed better in assessment in the content mastery when an intervention PBL approach is implemented. Besides, students who have actively participating in PBL can benefited with an improved critical thinking skills and problem-solving skills. This can happen when a student develops their collaborative skills as they are open in exchanging ideas in making the projects. Therefore, the current study shows that the PBL approach has a positive impact on students' scientific content knowledge as well as the development of skills like teamwork, critical thinking, and problem-solving in real-world scenarios (Gangwar, 2017).

The outcome of student experiences is in line with the perspective of Aryanti et al. (2021) that the project-based learning approach aids in enhancing the creative thinking skills of students studying biology. Utilizing the environment around them is a beneficial method for concentrating student engagement in biology studies. It enables them to collect data and guides them to conduct scientific research and formulate queries based on their surroundings. In biology learning, students' creative thinking skills must be fostered so that they can conceive ideas or address problems that arise during the learning process. Subsequently, curriculum developers and implementers must take a lead in the amendment of the curriculum in order to intensify the integration of project-based learning model. It should give weight on the content areas of General Biology 1, which are Cell, Biomolecules and Energy Transformation. By doing such way, the student will be more engaged in active learning experience. In this way, students apply their knowledge and skills by doing such meaningful activities that develops their creativity and problem-solving skills.

The outcomes show a significant difference in the pretest and posttest across the cognitive skills of General Biology 1, namely Comprehension, Analysis, and Application. A considerable difference implies that the student's cognitive skills improved after an intervention was administered. Furthermore, a significant increase of the overall mean percentage score in the cognitive skills indicates that project-based learning approach enhance the creativity skills of the students by applying what they learn from the discussion and translate it into practice by making the project task. This coincides with the study of Sinurat et al. (2022) that a student who participated the project-based learning can significantly enhance their creative thinking skills as compared to the control class. Further, in MANOVA analysis, pupils in the experiment class scored 76% in the high category and 63% in the medium category for creative thinking skills and learning outcomes.

Moreover, the outcome is in line with the perspective of Rumahlatu & Sangur (2019) that PBL has a significant effect on the metacognitive skills of the students. The study further suggests that an increase of metacognitive skills of the students can lead them to better understanding and retention of concepts.

In addition, educators should facilitate the students to develop their metacognitive skills in such a way that they will be aware of their own thinking process. By implementing the project-based learning activities they can now set goals, plan their project task and ponder their progress. Also, teachers should make a way to scaffold learning by breaking down complex concepts into a more manageable one. This would help the students to graphs the lesson easily given the time constraint.

Contextualized Pedagogical Model in Senior High School Biology Students: subsequently, a contextualized pedagogical model has to be created to fill the gap of the low-performance level of students all through content mastery and cognitive skills. This would also be beneficial on the part of the teachers as they will be equipped with their pedagogical approach to facilitating 21st-century learners.

The proposed PBLA Model is comprise of a connected pattern of Objectives, Project Task, Pedagogical Approach, Person Involved and Expected Results. The OPPPE pedagogical framework is a systematic diagram that an implementer must used when integrating PBLA in the curriculum. Each box corresponds to a profound journey and substantial approach that teacher and student may develop a strong engagement of it once use it. The framework encourages the students to involved in an active learning environment where they are more engage, by having fun, sharing of ideas through collaborative interactions and construct ideas out of their personal experiences and shared experiences with their peers.

Objective

The objective as the first part of the model sets the direction of the project tasked. Objectives function as educational goals for learners, providing them with a distinct comprehension of the anticipated requirements. When goals are successfully articulated, students have a clear understanding of what they need to achieve and can track their progress towards reaching the intended learning outcomes. Also, it provides a clear direction for the production of assessments by defining the specific information, abilities, or competences that students are required to show. This guarantees that evaluations are in alignment with the learning goals, enabling instructors to precisely evaluate student accomplishment and provide significant feedback.

Project Task

These are various project activities to be implemented by teachers. The project task assured that all activities

imbedded on it are student-centered and promote active learning of the students. It is in the form of 3D Cell Model (using the recyclable materials), news reporting on the current event in Biotechnology, Cell Theory Infographics, Biotechnology New Report, Cell Cycle Flipbook, Cell Membrane Model Construction, Investigating Enzyme Action, Pineapple wine fermentation and Comic Strip or Storyboard. These bunch of project task promotes authentic learning. Authentic learning focuses on engaging learners with genuine, meaningful, and practical activities that are directly applicable to the real world and align with their interests. Students are actively involved in the process of exploring and investigating. Learning often involves the integration of many disciplines.

Pedagogical Approach

Pedagogical approaches include the many techniques, tactics, and ideologies used by educators to aid the acquisition of knowledge and foster the growth of students. These methods comprise a diverse array of instructional strategies, philosophies, and concepts with the goal of actively involving learners and promoting their cognitive, social, and emotional development. Here are many prevalent instructional methodologies: constructivist approach, collaborative approach, reflective approach, integrative approach, and the inquiry-based approach.

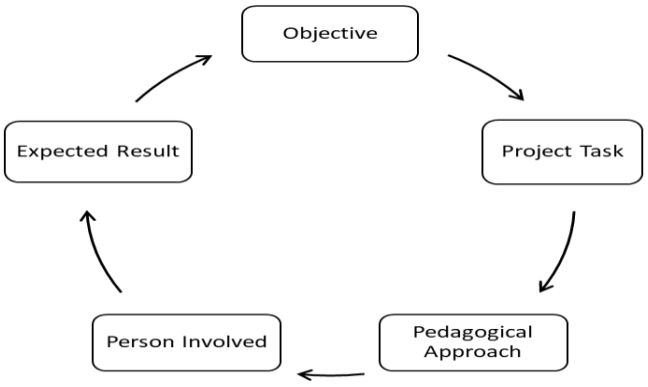
Person Involved

The direct person involved in this model is the teachers and the students. Teacher's role is a facilitator. He/She should act as a catalyze in promoting active learning environment that centers the welfare of students not just in the cognitive aspects but also, in affective and in psychomotor. Meanwhile, students are the recipient of the said model and expected to do their part in every project task given.

Expected Result

The expected result can assess on how the students do their project task. The student is expected to acquire essential skills from PBLA, such as critical thinking skills, problem solving skills, research skills, collaboration, creative thinking skills and self-management. Results are shown during their presentation to the class. In this way students are encouraged to ask questions and to share their thought towards the presentation.

Figure 1. OPPPE Pedagogical Framework



Source: own elaboration with the research data (2024)

Main limitations

This study has various limitations to consider. One of them is the need for more time in the implementation process. Since the project-based learning approach involves creating projects, there is expected to be a delay in submission on the part of the students. Students were allowed to finish it at home or outside the school provided that they take video documentation on how they came up with the projects and who was involved in the making, also with the consent of their parents. Still, the delay is observable. Aside from that, there are a lot of activities in the school that can contribute to such delays. This happened especially in the first semester of the school year when the subject was offered. One of them is the Division competitions in science (Science Quest) that were held in the said semester, in which the teacher assigned to teach general biology one (1) were busy preparing for the contest and expected to be out of school during the competition. Besides, October month also falls on this semester, when the Local Government Unit celebrates Araw ng Santa Cruz (The Day of Santa Cruz) and the month celebration for teachers or Teachers' Day, and all teachers are obliged to participate in the said activities. As a result, only Lesson Exemplar 1 to Lesson Exemplar 4 was implemented out of six (6) Lesson Exemplars. Hence, all of these circumstances can hinder the regular flow and phasing of the lessons and will result in a lack of time due to extended delays.

Secondly, some of the project materials are costly for the students. However, it was suggested that some of the projects used recyclable and indigenous materials. However, they are still expensive in their parts because they would buy something that contributes to the improvement of the projects.

Lastly, the quasi-experimental design adopted in this paper has some limitations. This design is less rigorous than a randomized controlled experiment, which would have enabled a more causal interpretation of the results. Also, the respondents are exclusively STEM students in Sta. Cruz National Senior High School, which results in a biased selection and defeats the universality of the study since it represents only one school in the entire division and region.

CONCLUSIONS

Based on the results and findings, the following conclusion were drawn:

1. Senior High School Biology students obtained low mean percentage score in the pretest and posttest across content mastery namely cell, biological molecules and energy transformation. This is interpreted as being in the beginning level.

2. General Biology students obtained low mean percentage score in the pretest and posttest all throughout cognitive skills namely comprehension, analysis and application. This is interpreted as being in the beginning level.

3. General Biology students were engaged in a Project-based Learning Approach because it involves active learning. It can boost student's creativity, reflection, critical thinking, and collaborative skills.

4. There is a significant difference in the pretest and posttest across content mastery.

5. There is a significant difference in the pretest and posttest all throughout cognitive skills

Recomendations

Based on the findings and conclusion, the following recommendation are offered:

1. Educators should revisit fundamental concepts when introducing new lessons to activate students' prior knowledge. Integrate Visual Aids like diagrams, models, and charts to comprehend abstract concepts. Involve the students the students on active learning methods by exposing them to interactive simulations, educational videos, and hands-on activities.

2. Educators should encourage critical thinking skills by giving them the opportunity to evaluate, analyze, and solve problems. Incorporate an Inquiry-based approach by exposing them to practical questions and assessment.

3. Educators should encourage students to learn collaboratively. In this way, students can freely discuss and exchange ideas with their peers and come up with a meaningful output.

4. Curriculum developers and implementers should intensify the integration of project-based learning approaches so that students will be engaged in active learning experiences. As a result, they may apply their knowledge and skills and develop their creativity and problem-solving skills.

5. Educators should facilitate the students to develop their metacognitive skills in such a way that they will be aware of their own thinking process. Teachers should make a way to scaffold learning by breaking down complex concepts into a more manageable one

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C. elaboration of figures and tables:	50%	50%
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