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Enhancing Students' Conceptual Comprehension and Problem-Solving Skills in Earth Science Through Project-Based Learning Method

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Abstract

The effectiveness of educational learning materials in refining students' performance is a subject of significant interest among educators. This study focuses on the effectiveness of project-based learning method in enhancing students' conceptual comprehension and problem-solving skills in earth science among the grade 10 learners of Banilad Night High School, Cebu City, Philippines during the academic year 2023-2024. By assessing the performance of students who received the experimental treatment compare to those in a control group, this study aims to design a specific enhanced project-based learning material suitable to the needs of the learners. This study utilized a quasi-experimental design, incorporating a pre-test and post-test questionnaire derived from the Department of Education's Most Essential Learning Competencies (MELC). Statistical analyses, such as frequency, percentage, mean, standard deviation, t-test for two independent samples, and t-test for paired samples, were utilized to get the data. The lack of significant difference in the pretest performance of the control and experimental groups ($p>0.05$) implies that the performance from the two groups is comparable which means that they are assumed to have the same level of knowledge on the competencies that will be covered in the experiment. After implementing the enhanced learning materials and conducting post-test, the experimental group's performance was found to be significantly better than that of the control group. This explains that the intervention or the use of project-based learning method is effective in enhancing students' conceptual comprehension and problem-solving skills. These findings provide valuable insights for the potential benefits of utilizing enhanced project-based learning material to improve learning outcomes among the students. It can be concluded that project-based learning method is effective in enhancing students' conceptual comprehension and problem-solving skills as evident in the significant improvement on the posttest results from the experimental group exposed to the treatment. Thus, the results stress the importance of integrating both manipulative and practical learning experiences and its relevance into teaching practices. This approach cultivates self-directed and proactive learners who are not just a nation builder but a productive member in the society who are responsive to the demands of time. This research contributes valuable insights into educational practices and encourages further exploration of effective teaching strategies to enhance student learning outcomes.

Keywords: *Conceptual Comprehension, Enhanced Learning Material, Experimental Design, Problem-solving Skills, Project-based Learning Method*

Introduction

In recent years, there has been a growing interest in exploring innovative and effective teaching methodologies to improve students' conceptual comprehension and problem-solving skills in science education. In the Philippines, the curriculum of kindergarten to grade 12 Basic Education Program mandates every school and teachers to hone the skills and create a lifelong learner to become innovative, goal oriented, globally competitive individuals who are responsive to the demands of time. It is important to note from the historical basis that the early evidence of experiential education found from the conventional methods of teaching of Socrates who first applied the inquiry-based approach in teaching (Chester, 2012).

In connection with this, Project-Based Learning (PBL) has emerged as a promising pedagogical strategy that promotes active learning, critical thinking, and practical application of knowledge. Several theories support the use of project-based learning approach in science education. One of the most prominent theories is constructivism, which suggests that learning is an active process where learners construct their understanding of the world based on their experiences and prior knowledge. Project-based learning allows learners to build their understanding of concepts through hands-on experiences. It promotes learning engagement in this cycle by allowing them to experience a problem, reflect on their experiences, and apply their knowledge to solve it. PBL fosters a student-centered learning environment where learners explore scientific concepts through real-world problems and inquiries. By engaging in activities that relate to their interests and experiences, learners can develop a more profound understanding of scientific principles and how they apply to practical situations. Learners gain a deeper appreciation of scientific knowledge and its relevance to their lives, leading to a more meaningful and sustainable learning experience. It also provides students with opportunities to tackle complex challenges, develop hypotheses, design experiments, and analyze data. Through active participation in the problem-solving process, students hone their critical thinking, analytical, and creative skills as well as encourages collaboration and communication among students, fostering

teamwork and the ability to approach problems from different perspectives. Thus, PBL offers an immersive and hands-on learning experience, encouraging students to take on active roles as investigators and problem solvers in this fast-changing society.

According to the studies of Brundiers & Wiek (2013) and Krajcik & Shin (2014), Project-based learning (PBL) is an inquiry-based instructional method that engages learners in knowledge construction by having them accomplish meaningful projects and develop real-world products. It has roots in the educational theories and philosophies of several prominent thinkers, including John Dewey. He advocated for an experiential and hands-on education approach emphasizing learning through doing, problem-solving and real-world experiences. Tadifa (2015) states that government is giving attention to the field of Science and Technology which plays a significant role in education guided by provisions in the 1987 Philippine Constitutions. This provision mandates to promote quality education to all Filipino learners across in different educational levels and creating a safe and motivating learning environment accessible to all. Moreover, it also ensures that patriotism and nationalism are well inculcated along with the quality of instructions.

Luistro (2015), revealed that the realities of the modern world require a different kind of Filipino. A Filipino who are not just developed holistically but also a competitive individual who can showcase talents and skills in an international arena. These constitutes a modern Filipino youths who possess vision and right attitude relevant to industry needs applicable to the demands of world market. The education sector uplifts the modern Filipino learners through imposing a stringent and relevant curriculum and hands-on program for digital advancement, adaptive skills and empowered learning communities. Additionally, Krajcik and Shin (2014) indicated six hallmarks of PBL, including a driving question, the focus on learning goals, participation in educational activities, collaboration among students, the use of scaffolding technologies, and the creation of tangible artifacts. In another study, Ralph (2015) reviewed fourteen studies that adopted PBL in Science, Technology, Engineering & Mathematics (STEM) education. The results testify that PBL enables the students to gain more knowledge and skills by engaging in projects that solve real-world problems and complex situations. This method of learning is effective because it allows every learner to be active, decisive and involved in hands-on activities.

Nevertheless, the Code of Ethics of Professional Teacher Article III, Section 1 "a teacher is a facilitator of learning and the development of the youth; he shall, therefore, render the best service by providing an environment conducive to such learning and growth". It is indeed a role of the teacher to give the most appropriate and effective teaching methods that could elicit the learners interest in order to develop conceptual understanding and problem-solving skills. Nowadays, the global market gives significance to human resource. These are individuals who possess practical skills that can manipulate machines and provide the needs of every consumer in the society. Based on the study of Tadifa (2015), in order to utilize human resources effectively, they should be furnished with skills that can be acquired through education. Furthermore, Quint et al. (2018) emphasized that Project-based learning is a method that allows the learners to expose in an actual scenario and build their skills and competencies required for improvement and progress. Boss (2012) also reiterated that educators have long seen and understood the value of projects to help students learn new concepts.

The students' low academic performance in science subject aggravated by the covid-19 pandemic in the past few years became a big challenge for the teachers to enable the learners grasp comprehensively the lesson with mastery and competence. The insufficient supply of science equipment and the absence of science laboratory in Banilad Night High School also hinder the learning performance among the junior high school learners when it comes to experiments, manipulation and hands-on activities. This is evident in quarterly exam where majority of the learners unable to achieve the passing score.

The consolidated reports after every major exam also reveal that science subject obtained below the 75% Mean Percentage Score (MPS) compare to other subject areas. According to Ilayon (2014) the results of the National Achievement Test (NAT) given to public institutions in Cebu City showed apparent results of 53% and 57% in science were evident for the past few years. This is very clear that the results unable to achieve the 75% passing rate which significantly mean that student's performance also failed in achieving international assessments. These researches signify that immediate actions must be done to augment the level of learners' performance and achievement.

Furthermore, the researcher in this study was determined to examine the effectiveness of project-based learning method in enhancing students' conceptual comprehension and problem-solving skills in earth science among the junior high school learners of Banilad Night High School. The research intends to contribute to a broader understanding of how PBL can be tailored to meet the learners' specific needs and interests. Additionally, this study aims to provide valuable insights and discernment to the learners into the significant impact and utilization of project-based learning to science education and improve their competencies and overall performance both in academic and other co-curricular activities. Thus, the researcher decided to pursue this masterpiece in order to level up the quality science instruction and increase the significant output in the field of education. Ultimately, the study on PBL serves as a valuable step towards evidence-based educational practices, enriching the understanding of effective teaching and learning methods for fostering students' conceptual comprehension and problem-solving skills through enhanced project-based learning material.

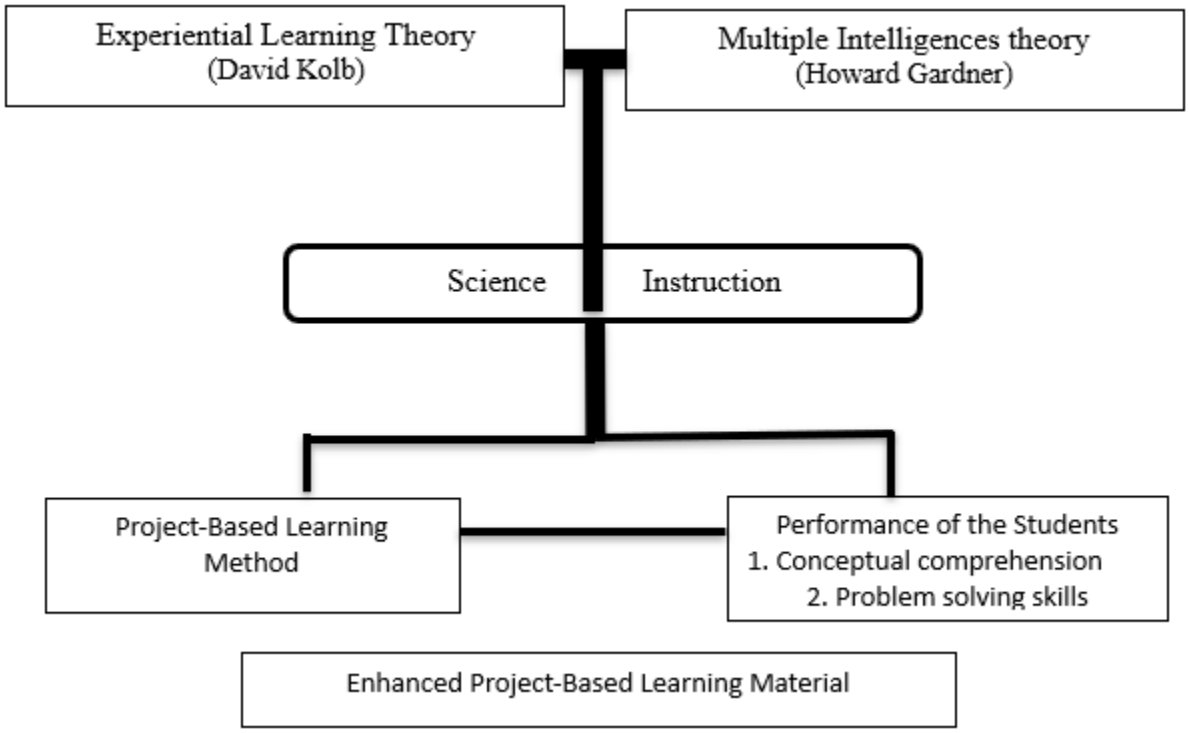
Theoretical Framework

In this study, the researcher anchored its theoretical framework from the Experiential Learning Theory of David Kolb. This theory of David Kolb (1984) is based from learning by doing in which learners engage in meaningful learning experience through hands-on activities and real-world application of knowledge.

In this theoretical framework, experiential learning theory serves as the backbone of this research journey where it plays a major role in the Junior High School science instruction. The researcher utilized project-based learning approach in the teaching-leaning process to assess and evaluate learners' progress and mastery on the most essential learning competencies. The control and experimental group in this study served as basis in determining the significant difference of PBL and conventional teaching methods towards the performance of the students. The findings of this study identified what specific enhanced project-based learning material can be made to amplify the students' conceptual understanding and problem-solving skills in science education.

In connection with this, learning through experience concentrates on the idea that direct experience and reflection is the best ways to learn things. Those experiences stick out in minds and help retain information and remember facts. It suggests that individuals acquire knowledge, skills, and attitudes by engaging in concrete experiences and

Figure 1.
Schematic Diagram of the Theoretical framework of the study



reflecting on those experiences to form abstract concepts and generalization. They utilize their profound knowledge and experiences to expound and serve as basis for the true meaning of their experiences and reflection. Through experiment it is where the students enable to utilize and apply the new set of learnings to the real world.

Experiential learning theory has been widely applied in various educational settings, professional training and development programs, as it fosters a deeper understanding, critical thinking skills, and the ability to apply knowledge in real-world situations. It also equips individuals to be ready in the field of works with the needed competencies and standard that meets the demand. Moreover, students who engage in experiential learning tend to perform better because they are already immersed in realia and actual application of the teaching and learning process.

Aside from experiential learning theory, this study was also anchored by the Multiple Intelligences Theory of Howard Gardner. In his book entitled, Frames of Mind: The Theory of Multiple Intelligences which was published in 1983, he

identified eight different intelligence areas and added one more intelligence area in the later years. Gardner (1993) described intelligence as a biopsychological potential that could be influenced by experience, culture, and motivational factors. According to him, intelligence is the ability to solve problems and to fashion products that are culturally valued.

Furthermore, the theory of Multiple intelligences challenges the traditional view of intelligences as a single general ability and instead proposes that people have arrange of different intelligences, each representing unique ways of processing information and learning. The significant contribution of multiple intelligences theory has attributed essential related studies and practices especially in the academe industry and has improved educators' perception on the different concepts of learning.

The content of Gardner's intelligence domains suggests some similarities to the group factors of hierarchical models of intelligence (e.g., Vernon, 1961), and Carroll (1993) has pointed out that Gardner's intelligences bear a striking similarity to the second-stratum factors of Carroll's hierarchy.

Statement of Purpose

The study aimed to determine the effectiveness of Project-Based Learning (PBL) in enhancing students' conceptual comprehension and problem-solving skills in earth science among the grade 10 learners in Banilad Night High School during the first quarter of school year 2023-2024 as a basis for enhanced project-based learning materials.

Specifically, the study sought to answer these questions:

1. What is the pre-test and post-test performance of the students in the control and experimental group for first quarter competencies in earth science in terms of:
   1.1 conceptual comprehension; and
   1.2 problem-solving skills?
2. Is there a significant difference on the pre-post-performance of the students in the control and experimental group?
3. Is there a significant mean gain on the pre-post-test performance of the students in the:
   3.1 control group; and
   3.2 experimental group?
4. Based on the findings, what enhanced project-based learning material can be developed?

Literature Review

According to Quint et al. (2018) Project-based learning is seen as an approach that empowers students to build up the 21st century capabilities - psychological and socio emotional abilities - required for progress. Boss (2012) said that educators have long seen and understood the value of projects to help students learn new concepts. Learners decide on approaching and solving problems based from the desired activities that suit to their needs and interests. Moreover, they acquire various knowledge and learning coming from multiple sources and assimilate the ideas derived on it in order to elaborate effectively the learning meaningfully. The learning is essentially important since it is congruent and related to the actual learning outcome which fosters better understanding of the lesson. Thus, students will be able to deepen their understanding and share the acquired knowledge and skills and are determined by how much they have understood the ideas and concepts.

The study of Brown (2022) Enhancing Students' problem-solving through project-based learning method, PBL was seen as an approach to be effective and efficient in order to engage learners in meaningful process of acquiring knowledge through investigation, exploration and solving real-world problems. This is evident in a classroom set up where teacher utilizes hands-on activities and utilize higher order thinking questions to elicit students' prior learning.

In connection with this, Bungihan (2019) on Problem-based learning approach enhances the problem-solving skills in chemistry of high school students found out that the problem-based learning approach used in the study has been effective in enhancing the problem-solving skills of the students. It pointed out that the more effective learning is problem-based compare to conventional approach in increasing students' practical and critical thinking skills of the learners as well as retention of knowledge and understanding.

On the other hand, the study of Delostrico (2019) Project-based Learning (PBL) in chemistry revealed that the pre-test and post-test of Conventional Approach and PBL groups have a significant difference existing between the academic performance of learners exposed to each group, in favor to Project-based learning group suggesting that Project-Based Learning is an effective teaching strategy that can be utilized in teaching chemistry to enhance the performance of the learners when it comes to academic. This implied that PBL is crucial in the field of science education.

Another study of Cakici et al. (2013) on the effect of project-based approach on learners' achievement and attitude in the subject science in Northern western park of Turkey, the students were divided into the control group and experimental group who underwent the intervention using project-based learning strategies. While conducting the experiment, the learners who made their project were keenly observed and monitored by the researchers in order to make it sure that they are the one who crafted it. Based on the result, there was significant difference of science achievement as its evidence on their collective learning effort.

Similar study conducted by Khaliq (2015) in one of the federal government high schools. According to his findings, learners who were treated to Project-based learning performed way better the other group who was exposed to traditional teaching approach. This implies that Project-based learning approach was proven effectively in providing science instructions since it fosters and elicit the curiosity, interest and attention of the students to navigate new areas of learning.

Meanwhile, Mayer (2016) investigated the students' perceptions of life skill development in project-based learning schools. Based on the findings, there was an improvement on students' collaboration, interpersonal skills, self-confidence and time management as a product of actual engagement among the students. It was also found out that the learners life skills and problem-solving has developed through the utilization of Project-based Learning which significantly showed the effectiveness of PBL towards their skills. Another study conducted by Redmond (2014) reports that project-based learning improves the academic achievement of the students through collaboration, active participation, and meaningful projects.

Methodology

Design
The study utilized a quasi-experimental research design. A research design in which two groups of students will be used as subjects. The experimental group utilized project-based learning approach in science instruction, while the control group employed the conventional teaching approach during the learning process. Both groups administered the pre-test and post-test design where respondents are tested both before and after exposure to an intervention or treatment. The pre-test established a baseline and the post-test measured any challenges that occurred due to the intervention, allowing researchers to assess the intervention's effectiveness. The difference between the performances of the students in the control and experimental groups in the study was analyzed and interpreted to establish the effect of the results. The findings were used as a basis for formulating appropriate interventions that would enhance the quality and effectiveness of teaching-learning process using project-based learning method.

Environment
The study was conducted in Banilad Night High School which caters the learners within the barangays of Banilad, Kasambagan and Talamban, Cebu City. It offers a complete high school curriculum with General Academic (GAS) and Technical Vocational and Livelihood (TVL) strands in Senior High School. BNHS is located within the vicinity of elementary department since we shared classrooms for the past years. Recently, BNHS is provided with own building and classrooms to cater the day shift learners. It has two main buildings: the Duterte building and Senior High School building. BNHS is a medium school composed of Principal, Assisting Principal, Administrative aide, 6 Senior High School Teachers and 23 Junior High School Teachers, with a total of 686 registered learners for A.Y. 2023-2024. There are 3 sections for each grade level both junior and senior high school except for grade 9 and grade 11 with 4 and 5 sections respectively.

The science teaching environment in the school is quite challenging especially with the kind of learners nowadays. Every one of them has their own pace and learning style that should be addressed during the delivery of the lesson. Furthermore, the student-teacher ratio is also a factor to be considered since class size has approximately 40 more students. Some non-specialize science teachers are handling science subjects because we lacked teachers in our school. There are no available textbooks yet since the department is still utilizing the modules crafted during the distance learning. The physical set up of the school premise lacks conduciveness during the teacher-learning process and the noise and temperature really affects the quality of students' attention span. However, teachers always find ways in coping these challenges by conducting Learning Action Cell (LAC) to improve the delivery of the lesson as well as to cater the needs of each learner. Aside from LAC, there's also a Focused Group Discussion (FGD) among the science teachers to discuss relevant issues in curriculum, competencies & current trends in science education to at least amplify the morale of every learner and boost their maximum potential to demonstrate science learning into real-life application. The school administration, parents and key stakeholders who are in conquest of quality education cognizant with DepEd's vision, mission, and core values, are marching forward in pursuit of quality K-12 Basic Education Programs

Participants
The respondents of the study were the 80 Grade 10 learners of the day shift in Banilad Night High School, which was subdivided into two sections. They were selected through cluster sampling intact group since they are all regular students who are currently enrolled for the school year 2023-2024. There were 40 random students chosen for pilot

testing from the night shift while the two groups assigned for experimental and control were drawn by lot. There were 40 students in the experimental group and 40 in the control group who participated in the research process.

Table 1.
List of Respondents

Grade	Section	No. of Students	Experimental	Control
10	**Aristotle**	**40**	**40**	
10	**Descartes**	**40**		**40**
TOTAL		**80**	**40**	**40**

This study utilized the cluster sampling technique. A cluster sampling technique is a probability sampling in which the population is divided into groups called clusters. The clusters are heterogeneous groups of the population in which the groups are divided differently based on the controlling variables. The participants were chosen randomly on selected cluster (s) and then, the rest of the members of the chosen cluster (s) became a part of the group. Moreover, cluster sampling is often utilized to study a bigger participants/population especially if the scope of the study is geographically dispersed.

Instrument
The researcher administered a teacher made pre and post-test questions derived from the Department of Education modules' Most Essential Learning Competencies (MELC) with first quarter topic for both control and experimental groups. There were 40 item questions for both the control and experimental group in which 20 items fall on conceptual comprehension and 20 for problem-solving skills based from the Table of Specifications (TOS). Prior to the administration of the research questions, the researcher conducted a pilot testing from the students in night department to ensure its reliability. The set of questions was reviewed by the school's science coordinator teacher and verified by a master teacher before the test was administered. The sampling test and validation was implemented after the approval from the adviser and the dean. These assessments were administered before and after the project-based learning intervention approach to measure students' conceptual comprehension and problem-solving skills. The comparison of scores helped evaluate the effectiveness of the intervention.

Data Gathering Procedure

Pre- Data Collection
The researcher underwent the preliminary phase of the research study wherein a title proposal was approved by the Dean which serves as focus and direction of this study. After that, the researcher prepared the chapters one to three for the design hearing. Then, it was submitted to the REC for technical and ethical review. When the REC approved to proceed the conduct of the study, the researcher did the following: First, the researcher asked permission from the Dean of the Graduate School for the approval of the study. Second, a written request was forwarded to the Department of Education – Division of Cebu City for superintendent's approval to conduct the research in the said division. Third, upon the approval of the said request, the researcher sent personally a copy of the approved letter to the school principal of Banilad Night High School. Prior to the actual data collection, the researcher carefully prepared the modification of the modules and set of questionnaires before it was given to the students. To ensure its reliability, the researcher administered a pilot testing from the students in night department. On the other hand, the set of questions were checked and validated by the school's district master teacher to ensure its validity.

Actual Data Collection
Then, the second phase (2) of data gathering was the implementation phase in which the researcher personally administered the data gathering to ensure high percentage retrieval. Orientation on the participants was conducted with regards to the purpose of the study. Instructions were given on how to answer the survey questionnaire. The respondents were asked to read and agree the consent form and the data conditions on this study prior to turning the next page. Assistance was provided to the respondents as the need arises. The respondents were given ample time to answer the questionnaires. During the actual data collection, the researcher administered pre-test questionnaires to the students to checked their prior knowledge. The set of questions are based from the most essential learning competencies during the first quarter. After administering the pre-test, the researcher implemented the project-based learning approach to the experimental group while traditional teaching strategy was utilized from the other group. The implementation of the intervention took eight weeks with the different hands-on activities and performance tasks given to the students. After the intervention phase, the researcher conducted the post-test to evaluate the learners' level of comprehension and problem-solving skills.

Post Data Collection
Lastly, for post implementation phase (3), the researcher retrieved all answered questionnaires form the respondents. The data gathered was carefully tallied, tabulated, analyzed and interpreted to arrive the predictive result of enhanced project-based learning material.

Data Analysis
The following statistical tools was used in the analysis and interpretation of **data: Frequency, Percentage, Mean and Standard Deviation was employed in analyzing the pretest and post-test performance of the students as well as for descriptive analysis on the students' pretest and posttest performance.**

T-test for Two Independent Samples was utilized in determining the significant difference between the scores in the pre-test of the experimental and control groups, and post-test scores between the control and experimental groups.

T-test for Paired Samples was utilized in determining the significant improvement of students' performance between the control and experimental group after being immersed in their respective instructional strategies.

Ethical Considerations
The study was conducted according to the guidelines outlined in the Declaration of Helsinki (World Medical Association, 2013). Approval was obtained from the Research and Ethics Committee of the University of the Visayas, with REC Agreement Code: NP2024MAED-022 dated February 5, 2024. The study involved adults who voluntarily participated in a face-to-face survey. Prior to completing the questionnaires, participants received an informed consent form detailing the study's purpose, procedures, risks and benefits, confidentiality measures, voluntary participation, and contact information. No financial incentives were offered for participation. The authors declared no conflicts of interest.

Moreover, this study underwent careful planning and conduct including the ethical requirements of this research. The researcher utilized various stages to resolve some ethical issues upon the completion of this research endeavor ensuring that rights and safety of the participants as well as the confidentiality of the respondents' responses to be tallied, analyzed and interpreted.

Results and Discussion

This chapter contains the presentation, analysis, and interpretation of the data gathered on the effectiveness of of Project-Based Learning (PBL) in enhancing conceptual comprehension and problem-solving skills in earth science among the grade 10 learners in Banilad Night High School during the first quarter of school year 2023-2024 as a basis for enhanced project-based learning materials.

Pre-Test Performance of the Control and Experimental Groups

The pre-test was conducted to determine the prior knowledge of the students from the control and experimental groups on competencies such as conceptual comprehension and problem-solving skills. The mean and standard deviation are utilized, and the results are shown in Table 2.

Table 2
Pre-Test Performance of the Students in the Control and Experimental Groups

Groups	Competencies	Mean	SD	Descriptive Equivalent
Control	Conceptual Comprehension	45.00	12.14	Did not Meet Expectation
	Problem Solving Skills	38.13	13.76	Did not Meet Expectation
	Factor Mean	41.56	10.01	Did not Meet Expectation
Experimental	Conceptual Comprehension	41.25	13.29	Did not Meet Expectation
	Problem Solving Skills	49.13	16.13	Did not Meet Expectation
	Factor Mean	45.19	13.04	Did not Meet Expectation

Note. n = 40. MPS- Mean Performance Score. 90-100% - Outstanding; 85-89% - Very Satisfactory; 80-84% - Satisfactory; 75-79% - Fairly Satisfactory; 74% and below – Did not Meet Expectation
The pretest performance of the students from the control group revealed that both the competencies of conceptual comprehension and problem-solving skills garnered a 45.00 and 38.13 mean respectively which denotes that the scores garnered from the learners are not that high. Thus, it did not meet expectation based on the descriptive equivalent. This implies that the students from the control group have less prior knowledge on the concepts from the given set of questions. It highlights that every learner has a prior knowledge or idea, interests and skills, beliefs and

attributes that influence significantly what they understand on the situation and how they organize in order to have a meaningful interpretation. This affects their ability to remember, reason, solve problems, and acquire new knowledge (Bransford & Cocking, 2000)

On the other hand, the pretest performance of the students from the experimental group achieved a 41.25 and 49.13 respectively from both the conceptual comprehension and problem-solving skill competencies. It is a little bit higher compare to the performance from the control group. However, based on descriptive equivalent, it did not meet expectation also. Similarly, the experimental group, lacked prior ideas about the topic from the questions. The results indicate that both groups performed below the expectation in the pre-test assessment, suggesting a similar baseline understanding of the topic. Thus, Project-based learning is seen as an approach that empowers students to build up the 21st century capabilities - psychological and socio emotional abilities - required for progress (Quint et al., 2018)

Post-Test Performance of the Control and Experimental Groups

The post-test was conducted to determine the knowledge of the students from the control and experimental groups on the competencies such as conceptual comprehension and problem-solving skills after the implementation of the intervention. The mean and standard deviation are utilized, and the results are shown in Table 3.

The post-test performance of the students from the control group indicates that conceptual comprehension garnered a 52.75 mean higher than the problem-solving skills with only 46.75 mean. This means that students have performed better in those items that involves conceptual comprehension than those with problem-solving skills. Moreover, it is evident that students' performance has improved even if the post-test performance still did not meet the expectation (Mean<75%) in the two competencies however it is better than their pre-test performance.

The post-test performance of the students from the control group indicates that conceptual comprehension garnered a 52.75 mean higher than the problem-solving skills

Table 3
Post-Test Performance of the Students in the Control and Experimental Groups

Groups	Competencies	Mean	SD	Descriptive Equivalent
Control	Conceptual Comprehension	52.75	14.36	Did not Meet Expectation
	Problem Solving Skills	46.75	14.17	Did not Meet Expectation
	Factor Mean	49.75	12.48	Did not Meet Expectation
Experimental	Conceptual Comprehension	63.00	19.18	Did not Meet Expectation
	Problem Solving Skills	56.38	18.54	Did not Meet Expectation
	Factor Mean	59.69	17.10	Did not Meet Expectation

Note. n = 40. MPS- Mean Performance Score. 90-100% - Outstanding; 85-89% - Very Satisfactory; 80-84% - Satisfactory; 75-79% - Fairly Satisfactory; 74% and below – Did not Meet Expectation

with only 46.75 mean. This means that students have performed better in those items that involves conceptual comprehension than those with problem-solving skills. Moreover, it is evident that students' performance has improved even if the post-test performance still did not meet the expectation (Mean<75%) in the two competencies however it is better than their pre-test performance.

Meanwhile, on the post-test performance of the students from the experimental group attained a 63.00 and 56.38 mean respectively from both the conceptual comprehension and problem-solving competencies. This entails that students have performed better in topics that involves conceptual comprehension than those with problem-solving skills. It signifies that learners have more knowledge and understanding on conceptual comprehension competency than problem solving skills after the intervention was given. Likewise, the post-test performance of the students in the experimental group still did not meet the expectation (Mean<75%) in the two competencies however it is better than their performance in the pre-test. This finding aligns with previous research that emphasized the importance of using instructional materials that are relevant and meaningful to students (Ashton, 2001).

Difference of the Pre-test and Post-test Performance Difference between the Control and Experimental Group

The difference between the performance of the students from the control and experimental groups was determined to establish the effectiveness of the intervention. The difference on the pre-test performance was executed to make sure that the students' performance in the two groups is comparable. On the other hand, the difference on the post-test performance of the students from the two groups was determined to identify what teaching strategy performed better. Moreover, the t-test for the independent samples was utilized in the analysis of data and the results are shown in Table 4.

Table 4
Pre-test and Post-test Performance Difference of the Students in the Control and Experimental Groups

Observations	Groups	Mean	SD	df	p-value	t-value	Decision	Interpretation
Pre-test	Control	41.56	10.01	78	0.167	-1.395	Failed to Reject	Not Significant
	Experimental	45.19	13.04				Ho	
Post-test	Control	49.75	12.48	78	0.004	-2.969	Reject Ho	Significant
	Experimental	59.69	17.10					

Note. Level of Significance α 0.05

In terms of the pre-test performance, the tabular values revealed that there is no significant difference in the performance of the students from the control and experimental groups ($p>0.05$). This implies that the performance of the students from the two groups is comparable which means that they are assumed to have the same level of knowledge on the competencies that will be covered in the experiment/intervention. Additionally, the results indicated that the p-value of 0.167, which is larger than the reference value, failed to reject the so-called null hypothesis. This suggests that there is no significant difference between the pretest performances of the students both in the control and experimental groups. It has important implications for the experiment to be conducted. The lack of significant differences in the pretest scores allows for a fair comparison between the control and experimental groups in assessing the impact of the intervention being tested. This provides confidence that any observed differences in the posttest scores can be attributed to the intervention rather than pre-existing disparities in knowledge or skills.

In terms of the post-test performance, the results showed that there is a significant difference in the performance of the students from the control and experimental groups ($p<0.05$). Moreover, the results revealed that the students from the experimental group have performed significantly better than the students from the other group. This explains that the intervention or the use of the project-based learning strategy is effective since PBL is an inquiry-based instructional method that engages learners in knowledge construction by having them accomplish meaningful projects and develop real-world products (Brundiers & Wiek ,2013; Krajcik & Shin, 2014)

Additionally, the results indicated that the p-value of 0.004, which is smaller than the reference value, able to reject the null hypothesis. It signifies that the intervention conducted has an enormous role in improving the performance of the students in both conceptual comprehension and problem-solving skills.

Pre-test and Post-test Mean Gain Performance of the Students in Control and Experimental Group
The mean gain on the students' performance from the pre-test and post-test of the control and experimental groups was determined to measure the effect of the teaching strategies utilized in each group. If these teaching strategies have a significant effect on the performance of the students after their implementation. Moreover, in the analysis of data, the paired sample t-test is utilized and the results are shown in Table 5.

Table 5
Mean Gain on the Pre-Post-Test Performance of the Students in the Control and Experimental Groups

Groups	Observations	Mean	SD	Mean Gain	df	p-value	t-value	Decision	Interpretation
Control	Pre-test	41.56	10.01	8.19	39	0.005	-2.999	Reject Ho	Significant
	Post-test	49.75	12.48						
Experimental	Pre-test	45.19	13.04	14.50	39	0.000	-4.199	Reject Ho	Significant
	Post-test	59.69	17.10						

Note. Level of Significance α 0.05

The tabular values revealed that the performance of the students from the control group has significantly improved after the implementation of the conventional teaching strategy ($p<0.05$) and has a mean gain of 8.19. This implies that the students' level of knowledge on the competencies has been enhanced after they were taught using the teaching strategy. The significant differences between the pretest performances in both the control and experimental groups is manifested by the rejection of the null hypothesis. This suggests that there is still an improvement of the students' performance even if they are not immersed into the experimentation process.

Additionally, the results revealed that there is a significant mean gain of 14.50 on the performance of the students from the experimental group after the implementation of the intervention with a p-value of 0.000 ($p<0.05$) leading to the rejection of the null hypothesis. This implies that the performance of the students has significantly improved

after they are immersed in the intervention. These findings align with the research by Sindelar (2010), which emphasizes the importance of providing hands-on experiences for students to enhance their learning effectiveness. It is significant to provide enough opportunities for learners to manipulate and engage actively in meaningful learning experiences to maximize their full potential for a better learning outcome.

Difference between Mean Gain Performance of the Control and Experimental Group

The difference between the mean gain performance of the students from the control and experimental groups was determined using the t-test for independent samples. This evaluates the mean gain performance of the students from two groups.

Table 6

Difference between Mean Gain Performance of the Students in the Control and Experimental Groups

Groups	Mean	SD	df	p-value	t-value	Decision	Interpretation
Control	8.19	17.26	78	.011	-2.620	Reject Ho	Significant
Experimental	18.63	18.35					

Note. Level of Significance a 0.05

The tabular values revealed that the performance of the students from the two groups significantly differ from each other ($p<0.05$). Furthermore, the students from the experimental group ($\bar{x}$=18.63) performed significantly higher that the students from the control group ($\bar{x}$=8.19). This implies that students from the experimental group have enhanced their level of knowledge on the various science competencies after being taught using the problem-based learning method. Moreover, it is evident that the intervention being utilized showed a significant improvement on the students' conceptual comprehension and problem-solving skills.

The findings that the project-based learning method resulted significantly better post-test performance compared to the conventional teaching strategy carries several implications to science education. It highlights the importance of carefully choosing teaching methodologies and instructional materials to enhance student learning outcomes and foster greater interest and enthusiasm for learning (Bart & Mitchell, 2002).

It highlights the significance of aligning teaching methodologies with the specific needs and interests of the learners. Through the utilization of project-based learning method, teachers can create a sustainable learning environment that enhances students 'learning outcomes. Moreover, it has an emphasis that supports the idea that a student-centered learning is effective. This finding indicates that students learn better when they are actively engaged in the learning process. This implies a shift from a conventional teaching approach to a more student-centered one, fostering autonomy, creativity and innovation.

Conclusion and Recommendations

Conclusion

The study findings strongly support the effectiveness of project-based learning method in enhancing conceptual comprehension and problem-solving skills in earth science among the grade 10 students. The significant improvement in posttest results for the experimental group exposed to project-based learning method instruction stresses the importance of integrating both manipulative and practical learning experiences and its relevance into teaching practices. Though the results did not meet the 75% expectation, but statistically there's an increase on the mean gain performance of the students based on the effectiveness of PBL instruction. This showed that the intervention applied to the students from the experimental group who were immersed to real-world application, learning by doing, and practical skills are not just effective but a key factor in improving students' actual learning performance.

Meanwhile, there are several factors why students did not meet the said expectation. These are the lack of educational resources, financial constraint, classroom conduciveness, and students' intellectual capabilities in grasping and contemplating the lesson well. These factors are important to be addressed and prioritized in order to achieve a quality output and effective implementation of project-based learning method. However, the result of this study still aligns with the theoretical framework of David Kolb' Experiential Learning Theory and Howard Gardner's Multiple Intelligences Theory in which students learn best not just only through conceptual acquisition but also in an actual performance or demonstration to create a meaningful learning outcome.

Moreover, project-based learning method leverages students' meaningful learning experiences through performance-based outputs and able to amplify the learning outcomes by incorporating critical thinking and problem -solving skills. Additionally, project-based learning method plays an indispensable role in enhancing conceptual comprehension and problem-solving skills in earth science as it prepares the students for lifelong learning and equips them with the skills needed to thrive in diverse academic and professional environments. This method highlights its significant attribute in education sector as it promotes knowledge retention, skills acquisition, and practical application of learned concept

to real life situation. Thus, this approach cultivates self-directed and proactive learners who are not just a nation builder but a productive member in the society who are responsive to the demands of time.

Recommendations

Based on the results of this study, several recommendations have been identified that can help improve our profound understanding of project-based learning method in enhancing conceptual comprehension and problem-solving skills in science education. Moreover, these recommendations will not just guide future researchers and inform best practices in secondary science curriculum but also connecting with real-world issues or students' interests, fostering deeper engagement.

1. Develop and implement enhanced project-based learning materials across all DepEd schools in Cebu City Division. This will help students better understand scientific concepts as they can relate them to their context and environment.
2. Conduct training and professional development programs for teachers in Cebu City Division on the effective utilization of enhanced project-based science learning materials in their teaching practices. This will help teachers integrate these materials into their curriculum and delivery methods, leading to better student engagement and practice.
3. Monitor and evaluate the implementation of enhanced project-based science learning materials in Cebu City Division to ensure they are being utilized efficiently and achieving the intended outcomes. This will help identify improvement areas and provide feedback for future development and implementation.
4. To address possible weaknesses in the study, the Division of Cebu City should consider transforming education using project-based learning method, crafting enhanced project-based learning materials, and adopting multiple-intelligence and experiential learning strategies. Proposed research titles based on policy, practice, and research innovation should be considered, and future researchers are encouraged to conduct similar studies.

Therefore, the researcher recommends the following research titles:

- Assessing the Effectiveness of Project-Based Learning Method in Enhancing Student Learning in Public Secondary Schools:
- Examining the Implementation of Project-Based Learning Method in DepEd Schools: Challenges and Opportunities.
- The Lived Experiences of Public School Teachers in Implementing Project- Based Learning Method: A Phenomenological Study
- From Rote to Real: How Project-Based Learning Transforms Student Engagement and Retention
- Designing Effective Project-Based Learning Frameworks: Best Practices for Educators`

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