Effectiveness of Project-Based Learning on Science Achievement of Grade 8 Learners at Fidel Zarceno National High School

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Abstract — The effects of Project-Based Learning (PBL) on Grade 8 students' scientific performance at Fidel Zarceno National High School was investigated in this quasi-experimental study. Two full groups—38 students in an experimental group and 37 using conventional approaches—were formed from seventy-five pupils. Over six weeks, both groups examined identical materials in line with the Most Essential Learning Competencies (MELCs), especially with regard to mitosis, meiosis, and genetic inheritance. Pre- and post-tests were a 50-item verified multiple-choice test.

Although both groups raised their post-test scores, the PBL group exhibited notably more improvement. Independent samples t-tests found no appreciable variation in pre-test results ($p > 0.05$), therefore indicating similar baseline knowledge. Comparisons following the test, however, revealed a notable advantage for the PBL group ($p < 0.05$). For both groups, paired samples t-tests verified notable within-group improvements ($p < 0.05$); however, the experimental group showed larger effect sizes.

Particularly in public schools with limited resources, the results support PBL as a useful and efficient teaching method. It promoted active participation, peer teamwork, and critical thinking. The study emphasizes how PBL might help to close differences between planned curriculum changes and actual classroom environments. It advises more PBL should be used, together with appropriate teacher support and training.

Keywords — Project-Based Learning (PBL), Science Achievement, Inquiry-Based Learning, Philippine K–12 Curriculum, Educational Innovation, Rural Public Schools, Critical Thinking, DepEd MELCs, Contextualized Teaching, Instructional Strategies.

I. Introduction

Science education has under increasing strain in recent years to move from rote memorization to active, inquiry-based learning. Methodologies like Problem-Based Learning (PBL) have been popular for their ability to include students in real-world problem solving as 21st-century skills and global standards in education have emerged. Driven by student-centered learning, PBL promotes group projects, critical thinking, and the building of meaningful knowledge. International studies confirm that it improves scientific performance (Belland et al., 2021; Hmelo-Silver et al., 2020; Savery, 2019); however, many classrooms—especially in underdeveloped countries like the Philippines—remain mired in conventional, lecture-heavy models.

Learner-centered approaches are included into the Philippine K–12 curriculum, however their implementation usually falls short. Science courses at Fidel Zarceno National High School still mostly rely on textbook material and teacher-led instruction. Teachers find it difficult to embrace alternative approaches due to constraints including lack of training, few resources, and rigorous curriculum schedules. Few chances for students to apply information to real-life issues, develop scientific thinking, or engage in meaningful peer collaboration abound. These circumstances draw attention to the rising discrepancy between classroom reality and desired reforms for education (Tabbada & Panganiban, 2021; Corpuz & Luna, 2020).

In response, this study investigates how Problem-Based Learning might be used to raise Grade 8 science performance at Fidel Zarceno National High School. Inspired by constructivist, social, and experiential learning theories, the study looks at whether PBL might be a useful and efficient tool for improving students' grasp of difficult scientific subjects including mitosis, meiosis, and genetic inheritance. The objective is not just to evaluate a strategy but also to identify a workable solution that meets the real difficulties experienced by rural public school science teachers and students.

This research specifically aims to:

1. Measure the pre-test and post-test science achievement of students exposed to PBL versus those taught through traditional instruction.

2. Determine whether there are significant differences in science achievement before and after the intervention within and between both groups.

   The study tests the following null hypotheses:

   - There is no significant difference in the pre-test scores between students exposed to PBL and traditional instruction.
   - There is no significant difference in the post-test scores between the two groups.
   - There is no significant difference between pre- and post-test scores within each group.

The study is significant to many different organizations. For students, it presents an opportunity to interact with science in more practical and hands-on manner. It offers teachers useful information on applying PBL in low-resource environments. It provides statistics on how closely teaching practices complement curriculum goals for policy makers and school leaders. Ultimately, for next generations of researchers, the study adds local data to an expanding field of inquiry-based education on a worldwide basis.

The study centers on 75 Grade 8 students from two current classes—one acting as the experimental group using PBL and the other as the control group using more traditional approaches. It addresses particular Grade 8 scientific subjects consistent with DepEd's Most Essential Learning Competencies (MELCs). Six weeks of study follow a verified multiple-choice test to gauge scientific performance. Though this design offers insightful analysis, its breadth, length, and evaluation instruments are limited. The findings may not apply generally across all schools or topic areas; they are most relevant in like school environments and grade levels. This study intends to demonstrate how PBL could close the gap between theory and practice by anchoring the research in a local classroom with real-world constraints. More than just evaluating a method, it aims to address a crucial question: Can an active, student-centered technique like PBL fit a standard public school science classroom—and if so, how?

Related Literature

Widely acknowledged as having great ability to improve students' academic achievement, critical thinking, and participation in science education is Problem-Based Learning (PBL). Rooted on constructivist learning theory, PBL gives students chances to investigate real-world issues, work with peers, and actively create knowledge rather than passively absorb it.

Savery (2019) presents a thorough overview of PBL's development and emphasizes its part in fostering deeper conceptual knowledge and problem-solving ability. Especially in science classrooms, Hmelo-Silver et al. (2020) underline the need of including technology in PBL contexts to assist cooperation and student-centered learning. Belland et al. (2021) also stress the need of scaffolding for guiding students through the problem-solving process, pointing out that this kind of support fosters inquiry-based skills and independent learning practices.

Notwithstanding these advantages, there remain implementation difficulties. Research by Lai and Hwang (2022) and Mergendoller et al. (2021) highlight problems like inadequate resources, poor teacher preparation, and uneven application of PBL ideas across classes. Thomas and Brown (2020) contend that a lack of practical training and institutional support for teachers accounts for the ongoing disparity between theoretical models of PBL and real-world classroom practices.

Research showing traditional teacher-centered approaches still predominate in scientific education points to the Philippines. Reliance on memorization and textbook-based learning limits pupils' development of scientific thinking and creativity, Tabbada and Panganiban (2021) find. Many educators lack the professional development required to boldly apply inquiry-based techniques like PBL, Corpuz and Luna (2020) say.

Outlining six basic components—driving questions, learning goals, engagement in scientific practices, collaboration, integration of technology tools, and creation of concrete outputs—Krajcik and Shin (2023) offer a revised PBL paradigm. These elements very nearly match the skills listed in the Philippine K–12 syllabus. De Guzman and Dizon (2022) nevertheless point out that empirical studies on PBL's efficacy in local schools—especially in rural and underfunded environments—remain scant.

Often noting variations in implementation integrity and teacher expertise, recent research as those by Hasni et al. (2021) and Condliffe et al. (2020) show conflicting results on the actual impact of PBL in real classrooms. In international research, Lee et al. (2021) and Nguyen and Hsieh (2023) demonstrate that well-supported PBL settings increase student enthusiasm and achievement in science. Still, turning these results into the Philippine educational scene calls for localized study with regard for contextual constraints.

The research shows the need of grounded, context-specific studies as well as the possibility of PBL to change science teaching and learning. More empirical data is required to direct efficient, sustainable PBL implementation, especially in public schools constrained in resources.

II. Methodology

Research Design

The efficacy of Project-Based Learning (PBL) on Grade 8 students' scientific performance was investigated in this quasi-experimental study using a design. This strategy is suitable for educational environments when controlled comparisons between groups are still possible yet random assignment is impossible (Creswell, 2014). Two intact classes—one acting as the experimental group and another as the control group—were chosen for this investigation. While the control group was taught using conventional techniques, the experimental group was given PBL strategy education. Pre-test and post-test scores indicated students' scientific performance, the dependent variable; the manner of instruction was the independent variable.

Participants

The study comprised 75 Grade 8 students from Carles, Iloilo's Fidel Zarceno National High School. Two groups were formed from the participants: 37 kids (49.3%) were assigned to the control group getting traditional education while 38 students (50.7%) were assigned to the experimental group employing PBL. Existing class sections guided the choice to preserve the natural classroom environment and guarantee instructional continuity.

Instruments and Materials

Designed to line up the Most Essential Learning Competencies (MELCs) in the Grade 8 science curriculum, a validated 50-item multiple-choice science achievement test was the main tool utilized for data collecting. Subjects addressed included basic genetic inheritance, the contrast of mitosis and meiosis, and the function of meiosis in preserving chromosomal count. The test was standardized and obtained from the Division of Iloilo; panel of specialists in scientific education verified its content validity. A table of specifications guaranteed even distribution of products over the intended competencies.

Additional resources included proven lesson plans catered for groups of PBL and conventional education. The researcher created these lesson strategies to help both groups to get materials consistently. Particularly in the PBL group, visual aids, activity sheets, and group projects like manila paper for group presentations helped to support interactive and hands-on learning opportunities.

Data Gathering Procedure

Three stages comprised the study: pre-experimental, experimental, and post-experimental. The researcher got informed permission from parents and student assent in the pre-experimental stage after securing required permits from the Schools Division Office. To get baseline information, both groups had pre-tests.

The experimental group attended PBL sessions over the six-week experimental period. Group projects, brainstorming meetings, graphic presentations, and practical problem-solving assignments comprised the activities. Beginning with mitosis and meiosis, each week concentrated on a particular scientific theme, then gametogenesis, and finally basic genetics and inheritance patterns. The control group, meantime, got lecture-based education on related subjects. To guarantee uniformity, the same teacher-researcher was instructed both groups.

Both groups received a post-test identical replica of the pre-test in the post-experimental phase. Particularly during group projects and project presentations, observations during teaching revealed that students in the PBL group exhibited greater degrees of engagement, teamwork, and critical thinking.

Data Analysis Techniques

Using the Statistical Package for the Social Sciences (SPSS), data were examined. Learners in both groups were described using descriptive statistics including frequency, percentage, mean, and standard deviation. The mean scores of the experimental and control groups were compared using independent samples t-tests; paired samples t-tests were used to examine variations within each group both before and after the intervention. Every statistical test has a significance threshold of 0.05.

Ethical Considerations

The study revealed ethical procedures all around. School officials granted written approval, and guardians and parents confirmed informed consent. Pupils freely agreed and were advised of their ability to withdraw at any moment. Every piece of data was kept private and used just for intellectual gain. The study followed moral guidelines for working with young people in an educational environment.

III. Results and Discussion

The study investigates the impact of project-based learning (PBL) on science achievement compared to traditional classroom instruction. The research questions implicitly addressed are:

1. Is there a significant difference in pre-test science achievement between students exposed to PBL and those in a traditional classroom setting?

2. Is there a significant difference in post-test science achievement between students exposed to PBL and those in a traditional classroom setting?

3. Is there a significant difference between pre-test and post-test science achievement within each group (PBL and traditional)?

Table 2: Pre-Test and Post-Test Science Achievement

Category	N	SD	Mean	Interpretation
Experimental Group (Pre-test)	37	3.22	13.73	Low
Experimental Group (Post-test)	37	5.29	36.89	High
Control Group (Pre-test)	38	3.89	12.79	Low
Control Group (Post-test)	38	4.32	25.74	Average

The pre-test findings reveal that both groups had a "low" level of scientific performance, suggesting equivalent previous knowledge. This is in line with Asman et al. (2022) and Hanif et al. (2019), who propose pupils struggle with abstract scientific concepts without enough prior knowledge. The uniformity of scores helps to justify the idea that notable learning variations only show up following intervention (Craig & Marshall, 2019). The post-test shows PBL's better influence as the PBL group achieves a "high" level and the control group achieves a "average". This is consistent with Asman et al. (2022), who found PBL improved academic achievement in STEM fields. The variability of scores in the PBL group and homogeneity in the control group help to underline even more how PBL fits to different learning styles than conventional approaches (Craig & Marshall, 2019; Chistyakov et al., 2023).

Table 3: Difference in Pre-Test Science Achievement

Pretest	Mean	SD	MD	95% CI (Lower)	95% CI (Upper)	df	t	p	Eta-squared
Experimental Group (Pre-test)	13.73	3.22	-0.94	-2.59	0.71	73	-1.14	0.259	0.02
Control Group (Normal Classroom)	12.79	3.89							

Pre-test scores reveal no appreciable variation in the independent samples t-test ($p = .259$), therefore verifying similar previous knowledge between groups. This fits studies stressing the need of similar groups for valid experimental design (Rubin & Babbie, 2023; Bhandari, 2022). This result is supported also by the small impact size ($\eta^2 = 0.02$).

Table 4: Difference between Pre-Test and Post-Test Science Achievement

Group	Pretest Mean	Pretest SD	Post-test Mean	Post-test SD	MD	95% CI (Lower)	95% CI (Upper)	df	t	p	Eta-squared
Experimental Group	13.73	3.22	36.89	5.29	-12.95	-14.35	-11.54	37	-18.65	<0.001	0.90
Control Group	12.79	3.39	25.73	4.32	-23.16	-25.01	-21.32	36	-25.48	<0.001	0.95

Both groups show notable increases according to paired samples t-tests (p <.001 for both). Both conditions show significant learning improvements shown by the large effect sizes ($\eta^2 = 0.90$ for PBL, $\kappa^2 = 0.95$ for control). Research showing PBL's efficacy in fostering deeper comprehension and involvement supports the PBL group's improvement (Hanif et al., 2019; Chistyakov et al., 2023; Asman et al., 2022; Kim et al., 2022). The notable improvement of the control group points to traditional education also producing favorable results, maybe by supporting fundamental knowledge (Craig & Marshall, 2019; Zhou et al., 2021; Asman et al., 2022; Miller & Krajcik, 2019).

Table 5: Difference in Post-Test Science Achievement

Post-test	Mean	SD	MD	95% CI (Lower)	95% CI (Upper)	df	t	p	Eta-squared
Experimental Group (Post-test)	36.89	5.29	-11.55	-13.38	-8.93	73	-10.01	<0.001	0.58
Control Group (Normal Classroom)	25.74	5.32							

Post-test scores (p <.001) of the PBL group reveal a notable variance according to the independent samples t-test. With $\kappa^2 = 0.58$, the significant impact of PBL on scientific performance is indicated by the huge effect size This is consistent with studies demonstrating how well PBL improves critical thinking, self-efficacy, and problem-solving (Asman et al., 2022; Hanif et al., 2019). The outcomes significantly support the introduction of PBL into science courses to encourage deeper knowledge and 21st-century abilities (Miller & Krajcik, 2019; Chistyakov et al., 2023).

Strong proof for the efficiency of project-based learning in improving science performance relative to conventional teaching is presented in this paper. Although conventional approaches also produce good results, PBL shows better influence especially in promoting different learning outcomes and greater This study shows that among Grade 8 students, both traditional education and Project-Based Learning (PBL) can result in notable increases in science performance. Still, the results unequivocally reveal that PBL-exposed pupils generated a greater spectrum of learning outcomes and scored better generally. Higher post-test results aside, these students demonstrated more customized progress and greater engagement, implying that PBL successfully supports deeper knowledge and varied learning demands.

While conventional teaching proved successful in reaffirming fundamental knowledge, PBL promoted higher-order thinking, problem-solving, and teamwork—skills critical in the context of modern education. The evidence points to PBL as providing a more dynamic and responsive learning environment, particularly in scientific education where inquiry and application are fundamental, even while both approaches are legitimate.

Moreover, the lack of a notable variation in pre-test results assures us that the two groups started from comparable degrees of knowledge. This supports the argument that the teaching strategies applied, not beginning variations in student ability, were the reason behind the noted gains.

These results lead one to advise several steps. First, schools—especially those in comparable rural or low-resource environments—should give Project-Based Learning some thought as a consistent teaching tool in scientific courses. Particularly when matched with the qualities listed in the K–12 curriculum, PBL is well-suited to foster critical thinking and more involved participation.

Second, professional development initiatives must to be given to let educators create and carry out successful PBL projects. Not only should training address lesson planning but also classroom management, assessment, and facilitation techniques supporting student-centered learning.

Third, authorities in schools and legislators should set aside funds for PBL-supporting instructional resources. These cover simple science kits, visual aids, shared offices, and access to pertinent technologies. Implementation of PBL depends on supportive infrastructure.

Fourth, one should investigate mixed learning approaches. Combining PBL with organized, direct instruction could aid solve deeper conceptual learning as well as subject mastery. Such integration guarantees that every student gains whatever their preferred learning style.

Finally, more investigation has to be done to investigate PBL's long-term consequences on scientific performance and possible implementation in other disciplines. Future research might also look at how PBL fosters the development of soft skills including communication, leadership, and teamwork—increasingly vital in holistic education.

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