Investigating the Effectiveness of Project-Based Learning in Primary Science Education: A Comprehensive Analysis

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Abstract

The current experimental study aimed to investigate the effectiveness of using a project-based method in teaching science at the primary level. This study was based on two main objectives: as to compare the performance of students studying science with that of those taught through the traditional lecture method, and the second objective is to assess the effectiveness of projects in engaging science students. This study was a quantitative study were two section of the students from grade 5th were selected as participants for the experiment. Section A was the experimental group, which was exposed to project-based teaching, whereas Section B served as the control group, which received traditional lecture-based teaching. Firstly, a pretest from the students to assess the baseline knowledge of both groups. After the intervention, which involved teaching Section A with projects and Section B with the lecture method, a post test was administered to both groups to measure their performance. The data collected from the pretest and post test were analyzed via SPSS. The results revealed significant differences between the post test scores of the control and experimental groups. The findings suggest that using project-based methods in the teaching of science has a positive effect on student performance. The interactive and visual nature of the projects likely contributed to enhanced engagement and better understanding of science concepts among the experimental group students. The project-based teaching approach created a dynamic and engaging learning environment, which fostered students' motivation and participation.

Keywords: Project-Based Method, Lecture-Based Method, Science Subject, Primary Students

Introduction

World standards for primary, secondary, and high school education are set in industrialized nations; emerging nations should aspire to match these standards by updating their curriculum. To help primary school students comprehend the importance of science more fully, some efforts are being made to address their needs through fresh approaches to education (Baysura., 2016).

In the twenty-first century, teacher-centered educational approaches have given way to student-centered approaches. Todaro and Smith (2011) emphasized the pivotal role of education in development, stating that it shapes human capabilities and is integral to progress. Education shapes the future by improving learning outcomes, as it aims to identify effective teaching methods for enhancing skills and comprehension (Sequeira, 2012). It also explores general learning advancement strategies, shedding light on school operations and the impact of teachers on student achievement; therefore, continuous professional development for teachers is crucial for improving student achievement (Ladele, 2018).

The National Policy on Education (2014) highlights primary education as a key driver of national development. High-quality education is vital for fostering capable citizens who contribute to socioeconomic progress (Ugwu, 2015). Johnson (2012) stressed education's role in national prosperity through literacy and a skilled workforce. Primary education lays the foundation for literacy and societal values. Innovative teaching, aided by technology, is necessary for effective learning (Ali, 2021). Critical thinking and diverse resources are essential for effective teaching (Khurshid & Ansari, 2012). Instructional strategies vary to meet diverse student needs (Espmaker & Tedenby, 2020). Contemporary teaching methods outperform traditional methods, enhancing student learning (Kiftiah, 2019).

Innovative teaching, which involves various techniques and resources, is essential for student success (Mandula, Meda, & Jain, 2012). Project-based learning, a common innovative method, fosters critical thinking and self-regulated learning (Filippatou & Kaldi, 2010). It engages students in real-world problem solving and promotes higher-order thinking (Stivers, 2010). Project-based learning, a student-centered approach, fosters collaborative problem-solving and 21st-century skills (Belayneh, 2021). However, its impact on learning outcomes is debated and requires further study and global implementation considerations.

OBJECTIVES

1. To explore the effectiveness of project-based learning methods in general science at the primary level.

2. To compare the performances of the students in science subjects who are taught via the lecture method with those of students who are taught via the project-based method.

1.4 RESEARCH Questions

1. What is the difference between the performance of science students who are taught with the lecture method and that of those who are taught with the project-based method?

2. What is the effectiveness of the project-based learning method in general science at the primary level?

HYPOTHESIS

To conduct this experimental research, the researchers developed the following null hypothesis.

HO: There is no significant difference between the performance of the science students who will be taught science by using the project-based method and the lecture method.

Methods and Materials

Research Approach

This study uses a quantitative research approach to explore the effectiveness of project-based methods in science at the primary level rather than the lecture method. As a result, some academics have described the PBL approach as a type of teacher education that emphasizes learning experiences and prepares teachers to implement instruction (Ball & Forzani, 2009; Grossman et al, 2018). This research involved the collection of numerical data and the use of statistical analysis via SPSS software. In this study, pre and post tests were conducted to assess student learning. The scores of the students were analyzed to explore the effectiveness of the project-based method in teaching science at the primary level.

Population, Sample Technique, Sample Size

Study Population

The population of study included 5th-grade students in the Public Sector Primary Level School of the Punjab Government**,** which is located in Rawalpindi city.

Research Sample

The participants of this study were as follows:

- The researchers herself participated in this experimental study as a teacher and taught section A the experimental group with intervention and section B the control with lecture method.
- A total sample of 38 students participated from each section i.e., A and B of 5th grade in this study.

Sample and Sampling Technique:

Through convenience sampling, the FG Sir Syed public high school, Rawalpindi, was selected for the study, as this school was assigned to the researchers for teaching practicums and research projects. Two sections, A & B, of the 5th grade were selected for the sample of the study; B was taken as the control group, and the other section constituted the experimental group. The first researchers administered the pretest to select participants. After the participants were taught the intervention, a post intervention test was administered to assess the effectiveness of the results and the effects of the teaching-learning intervention.

Research Instrument

In this study, the researchers investigated the students' performance in science, and 5th-grade students were selected to teach science. The topics were carefully chosen when students faced problems in grasping the concept. To conduct the study, two sections from the 5th grade

were used. One group was the control group, and the other was the experimental group.
No treatment was provided to the control group because the MCQS test was prepared for this control group, and a post test was performed for this pretest.
The experimental group was provided with a treatment in which the lecture method was applied during the pretest, and the post test was applied to the experimental group, which was provided with a treatment as a project-based method used for teaching science. One topic is selected to explore the effectiveness of project-based methods in science. This method was applied to science subjects to help the students experience the projects to analyze the topics. The lecture method is applied to science subjects, and the teacher applies the project-based method to investigate the students' performance. The topic was environmental pollution.
The pretest and post test were used as tools to explore the effectiveness of the project-based method on student performance. The experiment was conducted over a duration of 4 weeks. The total score on both the pre and post tests was 20. Both tests were in the form of objective and short response items with factual answers. In the test, seven blanks were included, seven Mcqs and three short answers were included. The test was designed to check students' performance. This pretest describes the student performance before the test, and the post test describes the student performance the teacher will give a lecture after they will examine the student performance for the applied post test. This teaching-learning intervention uses a teacher to check the student ability, and after this post test, the teacher examines the student's understanding of the concepts, the critical thinking skills improve, and their skills increase during the pre and post test.
Pre and post test: To study the effects of the project-based method in science at the primary level. This study investigated student performance in both the control and experimental groups. For the control group, the researchers used a questionnaire survey. The research tool used here, such as the questionnaire, had seven points for the blanks and the MCQs each and 9 points for the short questions, where each short question had three points. The pre and post test data of the control group were linked in this survey questionnaire, as no treatment was held in this group. The experimental group was tested for the pretest, which was performed via the same questionnaire as mentioned above. The post test was held on this treatment group of the PBL method. For the questionnaire, please see Appendix B.
PBL is an instructional approach that engages students in the learning process by enabling them to consider creativity in a given topic. The topic is "Environmental Pollution", which covers topics related to water, land, and air pollution. Teaching and learning involve a number of methods, but in science subjects, the project-based method is effective for student performance.
In the lecture method, the teachers instruct only the students' concepts, and their concepts are not clear; however, in the project-based method, the teacher will do something practically through this method, and the teacher will not give instructions, and the teacher will clarify the concepts through the project-based method. In my study, I investigated students through a project-based method; students were active learners, and they were engaged in hand-on activities. The teacher applied the pretest. This test is the survey questionnaire, and the teacher examined the student's previous performance through knowledge of the previous knowledge of the students. The teacher subsequently examined student performance through this project-based method and developed lesson plans for two groups: the control

group and the experimental group. The control group was given the lecture method, and they delivered only two lesson plans. The first lesson plan focused on the concept of environmental pollution. They used bingo cards for these activities, and students became familiar with this method. The second lesson plan focuses on the concepts of water, land, and air pollution. To reinforce the concepts of air, water, and land pollution. Prepare flashcards or small cards with names of different elements. Individual students are asked to come and pick a card. The teacher used the charts, pictures, white board and book notes. The teacher plans an evaluation plan for homework assignment and gives the students instructions for assignments.

They deliver the project-based method through five lesson plans, and the researchers shows the students different projects about specific topics. Like the first lesson plan, they delivered the concept of environmental pollution through videos to the students. In this lesson plan, the researchers asked the students to come and explain the points that they learned with the help of using projects. After this, the researchers asked another student to explain all the things that I taught them and write them on board through this activity, and the students increased their understanding of this topic.

Lesson plan two focuses on land pollution. The students know about land pollution, and through transfer of these projects, all ideas are transferred for development through projects. Lesson plan 3 focuses on water pollution, lesson plan 4 focuses on water pollution, and lesson plan 5 focuses on water, air, and land pollution. The researchers divided the students into groups A, B, C, and D and assigned the A group to land pollution, the B group to water pollution, the C group to air pollution, and the D group to air, water, and land pollution.

Ethical Considerations of the Research

Ethical considerations are crucial when conducting a study on the effectiveness of project-based learning in primary science education. First, informed consent must be obtained from both the students' parents or guardians, as the participants are minors, along with the students' assent to ensure they understand their participation. Anonymity and confidentiality must be maintained by anonymize data and protecting the identity of participants. It is also vital to ensure no harm comes to the students, either emotionally or academically, and that neither the control nor experimental group is disadvantaged. Fair treatment is essential, ensuring both groups receive equal instructional time and attention. After the study, debriefing the participants and their parents is important, especially if the findings suggest one teaching method is more effective. Data protection laws must be followed to secure the participants' information, and the research must be conducted with integrity, avoiding any bias or manipulation of results. Additionally, students and parents should retain the right to withdraw from the study at any point without consequence, ensuring participation remains voluntary. Transparency about the study's purpose should be maintained with all stakeholders, fostering trust throughout the research process.

Results

The study checked and measured the effects of the project in the form of students' performance on the science subject of 5th-grade students. For this purpose, a pretest and post test were administered, and the scores of both groups (control and experimental) were

analyzed statistically through SPSS. The results show that, compared with the lecture-based method, using a project based on teaching science subjects has a positive effect on students' performance. I applied the paired sample t-test to the control and experimental groups. The following table shows the mean difference in the pretest and post test scores of the control group.

Table 4.1

Mean difference pretest and post test scores of the control group

	N	Mean	STD
Pretest	38	5.2368	2.44324
Post test	38	14.1053	2.97990

Prior to innervation, the pretest scores of the fifth-grade students ranged from a minimum of 1 to a maximum of 10. The mean pretest score was 5.23, with a standard deviation of 2.443, indicating a level of prior knowledge among the students. After the lecture-based teaching intervention, the post scores of the students ranged from a minimum of 6 to a maximum of 19. The mean post score was 14.6, with a standard deviation of 2.97. The higher mean post test score shows that the level of students' knowledge increased after the pretest during the lecture.

Table 4.2

Pre- and post test scores of the experimental groups

	N	Mean	STD
Pretest	38	5.2368	2.44324
Posttest	38	14.6579	1.88579

Before the intervention, the pretest scores of the fifth-grade students ranged from a minimum of 1 to a maximum. The main pretest score was 5.23, with a standard deviation of 2.443, indicating that the scores of the students were affected by the use of the lecture method. After the intervention via the project-based method, the post test scores of the students ranged from a minimum of 12 to a minimum of 17, and the mean post test score was 14.657.

Independent sample T test 4.4

To compare two sample means from unrelated groups, the independent samples t-test was employed. This indicates that various individuals are contributing scores for every group. Determining whether the samples differ from one another is the aim of this test.

Table 4.3
Independent sample t-test

Group	N	Mean	STD	Mean Difference	Sig (2-tailed)	T-Test
Score1 (Control Group)	38	14.1053	1.8857 9	54207	338	966
Score2 (Experimental Group)	38	14 .6579	2.9799 0	57263	337	966

Group Membership: 1 Control Group and 2 Experimental Groups
This column indicates the group to which each participant belongs, where 1 represents the control group and 2 represents the experimental group.
N: This column shows the number of participants in each group. Both the control and experimental groups contained 38 compounds.
Mean: The mean column provides the average post test score for each group. The control group mean score is 14.105, and the experimental group mean score is 14.65.
STD. Deviation: This column indicates the standard deviation, which measures the spread or variability of the post test scores within each group. For the control group, the standard deviation is 1.88579, and for the experimental group, it is 2.97990.

Overall interpretation
- The control group (taught through a simple lecture method) had an average post test score of 14.10, with a standard deviation of 1.88.
- The experimental group (taught using the project) had an average post test score of 14.65, with a higher standard deviation of 2.9799.

On the basis of the results of the independent samples t test, we can confidently conclude that the experimental group, which was taught via projects, performed significantly better in the post test than did the control group, which was taught via a simple lecture method. Therefore, treatment involving the use of a project appears to be more effective in improving post test scores than the traditional simple lecture method is.

Discussion
The findings of the statistical analysis in this study have significant implications for educational practices, shedding light on the impact of using the project-based method as a teaching method rather than traditional lecture-based approaches. In the control group, the lecture-based method is used to find that these students are passive learners. This group finding indicates that the teacher and students do not actively participate in this group of findings. However, in the experimental group, the results indicate that the project-based method is very effective for student learning compared with student performance, and the findings of the 2nd experimental group are greater than those of the control group. This study revealed that the project-based method is more effective for student performance because science is a practical subject and that the lecture method is not valid for students; thus, the

researchers reported that students taught through the project-based method experienced increased student engagement and encouraged collaboration among students as they worked together to investigate scientific phenomena. According to Belayneh (2021), students engage in original program-related and frequently interdisciplinary group work to solve problems in project-based learning.

The collaborative environment using the PBL method promotes communication skills, as students discuss ideas, share findings and present their projects to peers and teachers. According to Hafeez (2017), the project-based method is a successful teaching strategy that can increase student engagement and aid in the acquisition of a better understanding of subject information through independent study.

This research shows that innovative methods such as the project-based method, when used in an instructional approach, are very effective for my students' learning performance. As students find the lecture method boring, the project-based method is very innovative, and students easily understand the concepts through hands-on learning activities, models, and experiments with the theories taught.

The findings of the statistical analysis in this study have significant implications for educational practices, shedding light on the impact of using the project-based method as a teaching method rather than traditional lecture-based approaches. The results from the independent samples t test were compared between the experimental group (taught with projects) and the control group (taught through a simple lecture).

One key factor that likely contributed to the higher post test scores in the experimental group was the visual and interactive nature of the projects as an instructional tool. Projects certainly have benefits in education. According to Ibragimov (2021), self-directed learning is included in project-based learning (PBL) to assist students in developing additional relevant learning content and problem-solving abilities. Students gain knowledge, approach and finish their job in a practical way, and present their own work. This is a model of instruction that lets you apply your own concepts. Consequently, learning through projects is a process-oriented strategy that necessitates engaging learning environments in classrooms. Students' science literacy and problem-solving abilities help them gain confidence by increasing the involvement and academic background required for success in higher education. According to Intykbekov (2017), PBL is a successful teaching strategy that can increase student engagement and aid in the acquisition of a better understanding of subject material through independent study.

These results are in line with the literature, as Yusuf (2020) reported that students' responsiveness rate increased through engaging them in activities. This study suggests that incorporating projects as a teaching method can lead to improved learning outcomes and greater student engagement. The interactive and visual nature of projects can effectively support students' understanding, retention, and critical thinking skills. Educators and curriculum designers should consider integrating such interactive teaching tools into their instructional strategies to foster an enriched learning experience for students. However, further research and exploration in different educational contexts would be beneficial to fully understand the potential and versatility of using projects as an effective teaching method. This study suggests that incorporating projects as a teaching method can lead to improved learning outcomes and greater student engagement. The interactive and visual nature of

projects can effectively support students' understanding, retention, and critical thinking skills. Educators and curriculum designers should consider integrating such interactive teaching tools into their instructional strategies to foster an enriched learning experience for students. However, further research and exploration in different educational contexts would be beneficial to fully understand the potential and versatility of using projects as an effective teaching method.

The hypotheses are rejected, so there is a significant difference between using lecture-based methods to promote involvement, which keeps students interested in what they are studying. Students can apply their academic knowledge to practical issues through projects that imitate real-world settings' help students improve critical thinking abilities by having them analyze issues, develop solutions, make decisions on their own students collaborate, communicate, and work in teams frequently, which fosters these abilities because PBL gives students a sense of control and autonomy to improve information retention and foster deeper learning.

Findings

1. PBL method enhanced student engagement in science at the primary level.

2. PBL method encourages collaboration among students, as they work together to investigate scientific phenomena and complete projects.

3. The collaboration environment promotes communication skills, as students discuss, share their understanding and present their projects to peers and teachers.

4. PBL encourages students to think critically and analytically as they explore real-world problems and find solutions.

5. When PBL is used in the teaching of science, student learning fosters long-term retention of knowledge.

6. Students demonstrated increased motivation and enthusiasm for learning, as well as improved problem-solving skills through hands-on exploration of real-world phenomena.

7. Collaboration and group work encouraged communication skills and peer learning, contributing to a more holistic understanding of scientific concepts.

8. The project-based approach emerged as a valuable tool for promoting active learning and fostering a deeper appreciation for science among primary students.

Conclusion

The following conclusions are drawn from the results of the independent sample t test, which is based on a statistical analysis of the data, comparing post test scores between two groups: the experimental group taught with projects and the control group taught through a simple lecture method. This study explored the effectiveness of project-based methods at the primary level. This study compares the performance of science students who will be taught via the lecture method and who will be taught via the project-based method. The findings provide evidence for the use of project-based method learning in education to develop students' core literacy, higher-order thinking skills and 21st century skills. The results show that, compared with 2 experimental groups, 1 control group lecture method can significantly improve students' learning outcomes compared with traditional methods and that the effects of project-based methods can be influenced.

Recommendations for Future Study/Future Implications

The following recommendations can be drawn from the findings of the study:

1. To enhance student engagement in primary science through PBL, hands-on activities and real-world connections should be utilized, fostering collaborative inquiry-based learning experiences.

2. Foster collaboration in PBL through group projects that prompt students to investigate scientific phenomena emphasizing teamwork and peer learning for holistic understanding and engagement.

3. To promote communication skills, encourage active participation in group discussions where students can articulate ideas, share findings and provide constructive feedback to peers.

4. Additionally, opportunities for students to present their projects to both peers and teachers should be facilitated, fostering confidence in public speaking and the ability to convey scientific concepts effectively.

5. Encouraging critical thinking in PBL by framing projects around real-world problems prompts students to analyze issues from multiple perspectives and develop innovative solutions, fostering their analytical skills and problem-solving abilities.

6. The implementation of PBL in science education to enhance long-term knowledge retention promotes active engagement, deeper understanding, and meaningful connections to real-world applications, thereby strengthening memory consolidation and recall over time.

7. The implementation of project-based learning in primary science education to increase student motivation, enthusiasm and problem-solving abilities through the exploration of real-world phenomena fosters collaborative group work to enhance communication skills and peer learning, facilitating a more comprehensive grasp of scientific concepts.

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