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The Impact of Project-Based Learning on 21st Century Skills in Teaching

Shiva Prasad Paudel
Lecturer, Depratemnt of Education, Dhawalagiri Multiple Campus, Baglung
Email: paudelshiva82@gmail.com

Abstract

This study is based on Project-Based Learning (PBL) in nurturing 21st-century skills among Class 9 mathematics students in Baglung, Nepal. Through teacher interviews and student focus groups, the study insight that PBL significantly enhances critical thinking by analyzing real-world data sets, improves problem-solving through practical applications in algebra and geometry, fosters collaboration in group projects related to mensuration and statistics, and strengthens communication skills through presenting mathematical solutions and findings. Challenges such as resource limitations and teacher training needs were noted, emphasizing the importance of adapting PBL to the local context. The study bridges a research gap in PBL implementation in Nepal and offers insights for integrating PBL effectively into mathematics education, paving the way for further research and improvements in pedagogical practices.

Keywords: Critical thinking and collaboration, local context adaptation, Nepalese math education project- based learning

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Introduction

Project-based learning (PBL) is a learner-oriented method of teaching that focuses on real-world problem-solving, collaboration, and inquiry-based learning. PBL involves engaging students in an extended, rigorous process of inquiry that culminates in a project or product that demonstrates their knowledge and skills. PBL emphasizes students take ownership of their learning and develop logical thinking, speaking and writing, practical knowledge and problem-solving skills.

The 21st century demands a skilled workforce equipped with critical thinking, collaboration, and technological literacy. Traditional pedagogical approaches such as rote memorization and lecture-based instruction (Freire, 1970; Darling-Hammond et al., 2008), may struggle to nurture these crucial skills in students may struggle to foster skills in students. The seeds of PBL can be found in the works of ancient philosophers like Confucius and Aristotle, who advocated for learning through discussion and engagement with real-world problems (Gutek, 2009). In the 20th century, the rise of progressive education, championed by John Dewey, emphasized student-centred learning and solving authentic problems, which align closely with the principles of PBL (Dewey, 1938). This philosophy laid the groundwork for the development of PBL. Dewey introduced the "project method" as a way to connect classroom learning to real-world situations (Kilpatrick, 1918). This method involved students tackling problems that required research, planning, and collaboration, similar to PBL projects. Now it is known as Project Method. The "New Math" movement in the mid-20th century, emphasizing conceptual understanding over rote memorization, also aligned with the goals of PBL in mathematics education (National Council of Teachers of Mathematics, 1964). It is the change in teaching math known as Mathematics Education Reforms.

In Nepal, innovative methods are needed to address this challenge. Equipping students with these skills requires innovative pedagogical approaches. To apply PBL in Nepal, teachers can start by selecting issues relevant to the learners' lives and requiring them to use a level of skills and knowledge. By incorporating traditional technical skills into PBL projects, students can gain an appreciation for their cultural heritage while also developing valuable technical skills and problem-solving abilities. Project-based learning (PBL) has emerged as a promising method to foster these skills across various subjects (Harris et al., 2009). The Partnership for 21st Century Learning provides the P21 Framework, a comprehensive resource that defines and outlines the essential skills students need to thrive in the 21st century. This is a valuable tool for researchers to identify and measure the development of these crucial skills through PBL projects in mathematics education. Traditional teacher-centred methods might still be dominant in Nepalese math classrooms. Research by Joshi (2017) explores the challenges of integrating technology (ICT) into Nepalese secondary schools, which could be indicative of a more traditional pedagogical landscape. Nepal's educational system is likely influenced by global trends in education. The growing emphasis on 21st-century skills and innovative teaching methods might have sparked interest in PBL as a potential approach. Studies haven't extensively explored the implementation and effectiveness of PBL in Nepalese math classrooms. This suggests that PBL might be a relatively new approach within the Nepalese educational system.

Project-based learning in math serves as a practical guide for educators on implementing Project-Based Learning (PBL) within mathematics classrooms. It offers strategies and resources to create engaging PBL experiences that challenge students and deepen their mathematical understanding. Moore & Burnett (2017). This study investigates the impact of PBL on student comprehension of ecosystems in science education. Although not specific to math, it demonstrates the potential of PBL to foster understanding within STEM (Science, Technology, Engineering and Mathematics) subjects, offering valuable insights for adapting PBL to teach mathematical concepts. Hmelo-Silver, C. E., & Barger, M. (2008) This article explores how Project-Based Learning can be utilized within K-12 mathematics education to cultivate crucial 21st century skills. It examines how PBL projects can encourage the development of critical thinking, collaboration, and technological literacy in students. Wang, & Sun (2015). This study explores the challenges and opportunities associated with integrating Information and Communication Technology (ICT) into Nepalese secondary schools. While

not directly focused on PBL, it provides valuable context for considering the potential challenges and opportunities of implementing PBL in Nepalese classrooms, which might have limitations in resources or technology infrastructure. Joshi (2017). This research investigates teacher perspectives and practices regarding technology integration in Nepalese secondary schools. Understanding teacher perceptions can be helpful when considering PBL implementation, as teacher support is crucial for its successful adoption. The impact of PBL on the development of 21st-century skills in Class 9 Mathematics within the Nepalese educational context. While research highlights the benefits of PBL in promoting critical thinking and collaboration (Bell, 2010). Particularly in developing countries, its effectiveness in mathematics education is not as extensively explored. Studies like Chiu et al. (2014) acknowledge a gap in research on PBL's impact on K-12 mathematics learning, Furthermore, adapting PBL for the unique circumstances of the Nepalese classroom necessitates further investigation. Class size limitations and resource availability pose distinct challenges compared to other contexts (Shrestha, 2018). This resource by the National Council of Teachers of Mathematics outlines the essential mathematical skills and concepts that should be addressed in K-12 education. It provides a foundation for researchers to tailor PBL projects to target specific mathematical concepts relevant to the Class 9 curriculum in Nepal, ensuring alignment with established learning objectives. National Council of Teachers of Mathematics. (2000).

Project-Based Learning (PBL) is an innovative teaching approach that emphasizes student-centred learning, inquiry, and real-world problem-solving. However, in the context of class 9 mathematics teaching in Nepal, several questions remain unanswered. In my experience as a mathematics teacher, I have observed that while traditional teaching methods focus on rote memorization and lecture-based instruction, they often fail to engage students in deeper learning or develop essential 21st-century skills.

In Nepal, the educational system is still largely exam-oriented, with limited opportunities for students to engage in collaborative and creative activities. This raises critical questions about the effectiveness of PBL in this context: Does PBL effectively encourage the development of 21st-century skills among students in mathematics learning? Specifically, how does it impact critical thinking, collaboration, creativity, and communication? Moreover, what challenges exist in implementing PBL within the context of mathematics teaching? Therefore, it is crucial to explore whether PBL can bridge this gap and how it can be effectively integrated into the existing educational framework. This study aims to investigate the effectiveness of Project-Based Learning (PBL) in encouraging the development of 21st Century Skills among students enrolled in Mathematics. Specifically, the study seeks to explore how PBL can be implemented and adapted within the context of Class 9 Mathematics teaching. By addressing these objectives, the study aims to contribute valuable insights into the pedagogical approaches that can effectively enhance students' mathematical skills and prepare them for the demands of the 21st century.

Investigating the impact of PBL on 21st-century skills is crucial. 21st-Century Skills development skills are essential for students' success in an ever-evolving world. PBL encourages students to think critically, collaborate effectively, and communicate their ideas, preparing them for future challenges (Bell, 2010). Similarly, Nepal's education system faces distinct challenges, including resource constraints and diverse student backgrounds (Mathema, 2007). Understanding how PBL can address these challenges and enhance learning outcomes is essential for teachers, researchers, and students (Krajcik & Blumenfeld, 2006). PBL promotes local relevance by integrating community-based issues and real-world problems into the curriculum (Thomas, 2000). Studying PBL implementation provides insights into effective teacher training and professional development. Teachers need support to design and facilitate PBL experiences that align with the curriculum and engage students effectively (Grant, 2002). PBL promotes active learning, engagement, and motivation. By working on authentic projects, students connect theoretical knowledge to practical applications, leading to a deeper understanding of mathematical concepts (Barron & Hammond, 2008).

The objectives of the study are to investigate the effectiveness of Project-Based Learning (PBL) in the development of 21st Century Skills in students enrolled in Class 9 Mathematics and to explore encourage PBL can be implemented and adapted within the context of Class 9 Mathematics teaching. The gap by examining how PBL can be implemented and

its effectiveness in encouraging 21st century skills amongst Class 9 mathematics students in Nepal. Building on existing research, this study aims to address these gaps by examining:

- How PBL can be implemented effectively to teach Class 9 Mathematics?
- The effectiveness of PBL in encouraging critical thinking, collaboration, and technology skills amongst Class 9 mathematics students.

Methods

This research will use qualitative approach to investigate the impact of Project-Based Learning (PBL) on the development of 21st century skills in Class 9 mathematics education within the Baglung district of Nepal. The study was used the **Convenience Sampling method** for selecting four secondary schools of Baglung and four subject teachers of each school will selected by purposive sampling methods. The study involved a sample of eight students of each school 2/2 each school of Class 9 which are selected by simple random sampling methods. Data collection was conducted through qualitative methods, including around 60 minutes for semi-structured interviews with four mathematics teachers (one from each school) and around 90 minutes for student focus groups. The interviews and focus groups were transcribed and thematically coded to align with the research questions and objectives. Initial open coding identified recurring themes, which were categorized into broader themes related to critical thinking, collaboration, and technology skills. This approach allowed for an in-depth exploration of the lived experiences of teachers and students within the math classrooms utilizing PBL.

Result and Discussion

The Effectiveness of Project-Based Learning

In exploring the effectiveness of Project-Based Learning (PBL) in fostering 21st Century Skills among Class 9 Mathematics students. They highlighted various insights tied to specific mathematical topics. For this, concerning sets and percentages, learners expressed improved critical thinking by analyzing real-world data sets, like local population demographics or market trends, to calculate percentages and make informed decisions. This aligns with teacher observations emphasizing students' enhanced problem-solving abilities and engagement when applying mathematical concepts such as algebra, geometry, and statistics to practical scenarios. Student focus groups provided valuable insights into their learning experiences. Students rolled the theories of Harris et al. (2009) by expressing how PBL made learning more engaging. They particularly enjoyed projects that connected mathematical concepts to real-world problems, like calculating percentages in household budgets or applying statistics to analyze local market data. This focus on local relevance aligns with the research gap identified by Chiu et al. (2014). Similarly, in mensuration and geometry, students demonstrated collaborative skills through group projects involving designing and measuring physical structures in their community. For example, they calculated the area and perimeter of public spaces or constructed models of local landmarks. This hands-on approach not only enhanced their spatial reasoning but also encouraged teamwork and communication skills, as noted by teachers during the interviews. This hands-on approach not only enhanced their spatial reasoning but also encouraged teamwork and communication skills, as noted by teachers during the interviews. Among the teacher interviews, one teacher noted, 'Students became more analytical when examining real-world data sets for statistical analysis.' Another highlighted, 'PBL projects encouraged students to think critically to solve complex problems related to budgeting for community events using algebraic methods.' Similarly, from the student focus group discussions, one student expressed, 'PBL made math more engaging, especially when we had to analyze market trends using percentages and statistical measures.' Another student chimed in, 'We enjoyed calculating the area and perimeter for public spaces; it made us think about real-world applications in geometry.'

For collaboration and communication, a teacher observed, 'Group projects on designing and measuring local landmarks emphasized teamwork and communication skills, particularly in understanding geometric properties such as angles and shapes.' Another teacher added, 'Students learned to explain their mathematical reasoning effectively while collaborating on projects involving trigonometric calculations for determining heights and distances.' From the students' side, one student shared, 'Working on projects with classmates helped us communicate our ideas and solutions more clearly, especially when tackling problems involving linear equations.' Another student mentioned, 'We learned to collaborate and delegate tasks while designing blueprints for community infrastructure, incorporating concepts of scale and proportion in our measurements. During the study, the activities of the teachers and students were studied according to the contents of math of class nine, from which the responses received are mentioned as follows:

Simplification of algebraic expressions and simultaneous equations were addressed through project tasks requiring students to solve complex problems related to budgeting for community events or optimizing resource allocation, showcasing their proficiency in algebraic manipulation and analytical thinking. Recent studies highlight the effectiveness of such approaches in enhancing students' problem-solving skills and engagement in mathematical tasks (González, Rodríguez, & Perez, 2021).

Indices, statistics, and probability were integrated into projects involving data analysis and interpretation, where students applied statistical methods to analyze trends or predict outcomes based on local data sets, enhancing their statistical literacy and logical reasoning (Soto & Barahona, 2021).

The construction chapter was approached through practical projects like designing blueprints for community infrastructure or creating scale models, which not only reinforced geometric concepts but also encouraged creativity and innovation among learners. Both teachers and students emphasized the need for adaptation to the local context. Teachers suggested modifying PBL projects to ensure closer alignment with the mathematics curriculum (Sharma & Shrestha, 2022). They proposed incorporating problems and examples that resonated with students in Baglung, potentially focusing on topics like local agriculture or small businesses for applications of concepts like sets, percentages, and basic algebra. The participant views and experiences underscored how PBL, when integrated with specific mathematical topics, effectively nurtured 21st-century skills such as critical thinking, problem-solving, collaboration, and communication, aligning with the overarching objective of investigating PBL's impact on skill development in students (Smith, Rodriguez, & Turner, 2021). However, teachers also acknowledged challenges, echoing other studies on PBL in resource-limited settings (Chen & Yang, 2021). Larger class sizes and limited resources in classrooms made it difficult to fully implement PBL for all mathematical topics, particularly those requiring extensive calculations or practical activities (Johnson & Lee, 2022).

Implementation of PBL within the context

In this objective from teacher views were obtained through semi-structured interviews and learner responses from focus group discussions. Teachers underscored the effectiveness of PBL in empowering 21st Century Skills such as critical thinking, problem-solving, collaboration, and communication, particularly evident in activities related to sets, percentage home arithmetic, mensuration, simplification of algebraic expressions, simultaneous equations, indices, geometry (parallelogram and triangle), construction, statistics, and probability. In the context of simultaneous equations, students engaged in projects requiring the application of algebraic methods to solve real-life problems such as budgeting for community events, thereby enhancing their analytical skills. Indices and statistics were incorporated into projects involving data analysis, where students analyzed local data sets to identify trends and make predictions, thus improving their statistical literacy and logical reasoning.

In geometry, particularly with parallelograms and triangles, students demonstrated collaborative skills through group projects. For instance, designing and measuring physical structures within their community helped reinforce geometric

concepts and spatial reasoning. Teachers noted that such hands-on projects not only solidified students' understanding of geometric properties but also fostered teamwork and communication.

The construction chapter was approached through practical projects such as creating blueprints for community infrastructure. This not only reinforced mathematical concepts but also encouraged creativity and innovation among learners. Both teachers and students emphasized the need for adapting PBL projects to align closely with the Class 9 mathematics curriculum, focusing on relevant local contexts such as agriculture or small businesses.

Similarly, a teacher suggested, "Modifying PBL projects to focus on local agriculture or small businesses could better engage students with sets, percentages, and application of algebraic expressions." Another teacher emphasized, "Aligning project topics with the Nepalese Class 9 mathematics curriculum ensures a deeper understanding of concepts." From student's sites, one student expressed, "It would be great to have projects related to our community, like analyzing data on local businesses." Another student added, "Using real-life examples from class discussion would make learning more relevant and interesting." On the other part of the research, a teacher acknowledged, "Large class sizes and limited resources make it difficult to implement PBL for all topics, especially those requiring extensive calculations or practical activities." Another teacher suggested, "Ongoing teacher training on PBL design and facilitation is crucial for successful implementation." During the study, Learners actively engaged in projects that involved calculating local market trends (percentages and home arithmetic), designing geometric structures for community spaces (geometry), and analyzing statistical data sets (statistics and probability). These projects showcased the students' enhanced mathematical reasoning and application abilities. For example, in the context of local market trends, students applied percentage calculations to analyze price fluctuations and consumer behavior. In geometry, students designed structures such as community playgrounds, applying their knowledge of shapes and measurements. In statistics, students worked with real data sets to identify patterns and make predictions.

However, several challenges in implementing PBL were noted, including resource limitations, time limitations, and the need for ongoing teacher training. Teachers focussed on the difficulty in accessing necessary materials and tools for projects, as well as the extensive time required to plan and execute PBL activities effectively. Additionally, teachers have expressed the need for more professional development opportunities to become proficient in PBL methodologies.

Participants also emphasized the importance of adapting PBL to the local context of Baglung. This adaptation involves incorporating culturally relevant examples that resonate with the student's daily lives and experiences, ensuring language accessibility for all students, and promoting community involvement in project design and presentation. By aligning PBL projects with local contexts, such as using examples from local agriculture or small businesses, teachers can make learning more relevant and engaging for students.

Conclusion

The study of Project-Based Learning (PBL) in Class 9 Mathematics revealed significant enhancements in students' 21st-century skills, including critical thinking, problem-solving, collaboration, and communication. Activities such as analyzing local market trends and designing community spaces reinforced mathematical concepts and engaged students in practical applications. Feedback from teachers and students emphasized the importance of contextualizing PBL to local contexts, such as agriculture and small businesses, for greater relevance and engagement. Despite the benefits, challenges like resource constraints, time limitations, and the need for ongoing teacher training were identified, reflecting findings from other studies on PBL in resource-limited settings. Addressing these challenges through continuous professional development and tailored project designs can further improve the effectiveness of PBL in developing essential skills in mathematics education.

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Shiva Prasad Paudel is lecturer in Curriculum and Evaluation and working in Department of Education of Dhawalagiri Multiple Campus, Baglung, Tribhuvan Univeristy, Nepal. Currently, Paudel is department head of department of teaching practice of Dhawalagiri Multiple Campus, Baglug.