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Student Engagement in Project-Based Learning Approach in Mathematics

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Abstract

The evolving landscape of education necessitates transformative approaches, emphasizing student engagement as a critical factor for effective learning. In this premise, this study investigated the impact of the Project-Based Learning (PBL) approach on student engagement in Grade 10 Geometry classes in a public high school in Arizona, USA during the Academic Year 2022-2023. Data for this descriptive study was collected from 199 Grade 10 Sophomore Geometry students in the above research environment using a self-made data-gathering instrument that has passed the rigorous tests of validity and reliability. The findings indicate that the majority of respondents were non-working female students enrolled in regular sections, with parents whose educational attainment were relatively modest. The ensuing analysis showed student engagement in PBL to be high across all essential factors of driving questions, sustained inquiry, authenticity, collaboration, 21st century skills, and public product. Moreover, no significant difference in student engagement were observed based on groupings by sex, student working status, and section for most PBL essentials. On the other hand, parental educational attainment played a pivotal role in shaping student engagement levels. The foregoing findings call for sustaining inquiry-based questions in PBL, recognizing family contributions, while revising class section policies to enhance collaborative learning environments.

Keywords: PBL approach, student engagement, PBL essential factors, Geometry, Arizona, USA.

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Introduction

Rationale

Education, like any other industry, must undergo profound change, and, to paraphrase Zhao and Watterston (2021), all stakeholders should seriously consider reimagining education. But doing so requires a shift from traditional models to more flexible, inclusive, and student-centered approaches. Correspondingly, for education to evolve effectively, it is crucial to focus on student involvement in the classroom. Evidence in support of this position can be found in Yulhendri et al. (2022) who state that involving students in what they are learning will result in student engagement, improving student learning performance.

In the words of Barkley and Major (2020), student engagement refers to "the mental state students are in while learning, representing the intersection of feeling and thinking" (p. 6). Numerous studies on the phenomenon known as "the emotional salience effect on memory" have shown that when students are feeling and thinking simultaneously as they are learning new concepts, their feelings make it easier for them to retain new information than when they neutrally retain it (Yin et al., 2023). This intersection of feeling and thinking while learning (student engagement) is often observed when students have high interactions with other individuals, ideally with their peers and lecturers (Yulhendri et al., 2022). Student engagement is essential to effective education, as it enhances students' motivation, learning, and overall academic success.

Among Grade 10 Geometry students at Canyon View High School, notable learning gaps in student engagement have been observed when implementing the PBL approach in math classes. This highlights the need for further investigation into its impact on student engagement, particularly after applying the approach in a real classroom setting.

Objectives

This paper aimed to determine the level of student engagement in PBL approach in Mathematics at Canyon View High School, Arizona, throughout the Second Semester of the Academic Year 2022-2023. More specifically, this paper sought to determine 1) the extent of student engagement in PBL approach in mathematics in terms of seven PBL essentials; and 2) the significant difference, if any, in the level of student engagement in PBL approach in Mathematics at the research environment based on demographic groupings.

Literature Review

This section provides an overview of the body of knowledge on the PBL approach, essential for deepening the understanding of the subject under investigation. It incorporates insights from both local and international researchers who have significantly influenced the variables studied.

At the onset, student engagement is a critical factor in the success of PBL, particularly in mathematics, where active participation and contextual learning are essential. Engagement in PBL stems from its alignment with constructivist principles, emphasizing collaboration, problem-solving, and real-world application. According to Larmer et al. (2015), the PBL approach integrates key essentials such as driving questions, sustained inquiry, and authenticity, fostering deeper engagement. In mathematics, these elements are instrumental in encouraging students to explore, analyze, and apply mathematical concepts in meaningful ways.

Driving questions, for instance, serve as the foundation of PBL by presenting open-ended, real-world problems that challenge students to think critically and creatively. These questions guide the

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learning process and ensure relevance, motivating students to actively engage in mathematical exploration. Shin et al. (2021) emphasize that driving questions foster inquiry-based learning, prompting students to develop computational models and address complex issues. By connecting mathematics to everyday experiences, driving questions help sustain student interest and focus throughout the project.

Next is sustained inquiry, a hallmark of PBL, requiring students to continuously ask questions, investigate, and refine their understanding over time. This iterative process promotes deep learning and engagement as students work collaboratively to address the driving question. According to Jansen (2020), sustained inquiry in mathematics encourages students to assess their prior knowledge, identify learning gaps, and seek solutions through research and experimentation. This approach not only builds problem-solving skills but also fosters a sense of ownership and perseverance in learning.

Meanwhile, authenticity in PBL connects mathematical concepts to real-world contexts, making learning relevant and meaningful. Students are more engaged when they perceive the content as applicable to their lives or future careers. Larmer and Mergendoller (2015) argue that authentic projects inspire students by addressing issues that matter to them, enhancing their motivation and effort. In mathematics, authenticity can involve solving practical problems, such as budgeting, data analysis, or engineering challenges, which demonstrate the subject's value beyond the classroom.

Collaboration is another essential component of PBL that enhances student engagement. By working in teams, students learn to share ideas, negotiate, and build on each other's contributions, reflecting Vygotsky's socio-cultural theory of learning. Research by Moliner and Alegre (2020) highlights the importance of collaboration in developing communication and interpersonal skills while solving mathematical problems. Group dynamics in PBL encourage peer learning, foster accountability, and create a supportive environment where students feel empowered to take risks and innovate.

The PBL approach integrates the development of 21st-century skills, such as critical thinking, creativity, and digital literacy, essential for success in today's world. By culminating in a public product, PBL provides students with opportunities to present their work to an audience, which further enhances their engagement and sense of achievement. Chen and Yang (2019) found that public presentations or demonstrations of mathematical projects boost confidence, reinforce learning, and allow students to connect their efforts with tangible outcomes. This process also prepares students for real-world challenges, where teamwork and effective communication are paramount.

Engagement in mathematics through PBL is deeply rooted in its essential elements—driving questions, sustained inquiry, authenticity, collaboration, 21st-century skills, and public product. These components work together to create a dynamic and interactive learning environment that motivates students to actively participate and connect mathematics to their lives.

Methodology

This chapter discusses the methods used to gather and analyze the data based on this papers' predetermined objectives. This section includes the research design, subject-respondents, research instrument, data collection procedures, and ethical considerations, and data analysis and statistical treatment.

Research Design

This study used the descriptive research design aiming to determine the extent of the PBL approach in Mathematics tailored for Grade 10 Sophomore Geometry students at Canyon View High School in Waddell, Arizona, during the Second Semester of the School Year 2022-2023. Generally, descriptive research design is a sort of research design that systematically gathers data to characterize a phenomenon, circumstance, or population being examined, according to Siedlecki (2020).

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Respondents

This paper used stratified random sampling to determine the study respondents from Sophomore Geometry Students (N= 410; n=199).

Instrument

The survey questionnaire covered 42 items for student engagement in PBL Essentials in Mathematics, with 7 items for driving questions, sustained inquiry, authenticity, collaboration, 21st-century skills, and public products. Each item was rated on a scale of 1 to 5, using a 5-point Likert scale rating with 5 as always, 4 as very often, 3 as sometimes, 2 as rarely, and 1 as never. Participants were asked to assign a numerical value to their responses based on their perceptions, experiences, or preferences for each question within the given category. The scale ensures quantitative data to be used to analyze and interpret the participants' sentiments systematically.

Procedures for Data Collection

A formal request was sent to the Division Superintendent after establishing the validity and reliability tests of the research instrument. Upon approval, the said letter was distributed to the School Principal for subsequent reliability testing. Questionnaires were then administered to teachers-respondents through Google online survey form to ensure safety and ensure 100% retrieval of the data.

Data Analysis and Statistical Treatment

Objective 1 used the descriptive-analytical scheme and mean as a statistical tool to determine the extent of the student's engagement in PBL approach in mathematics in terms of the PBL essentials of driving questions, sustained inquiry, authenticity, collaboration, 21st Century skills, and public product. Objective 2 used the comparative analytical scheme and Mann-Whitney U to determine the extent of the student engagement in PBL approach in mathematics based on the same seven PBL essentials above when grouped according to demographics.

Ethical Considerations

This research paper strived to minimize the risk of harm to its target respondents by assuring them of the confidentiality of their responses and ensuring their anonymity throughout the entire research process. At the onset, this paper secured their free, prior informed consent and assured them of their right to withdraw from their research participation if deemed necessary. No personal data compromising the respondents' identity was collected in adherence to the Family Educational Rights and Privacy Act (FERPA), specifically on accessing the data both by the researchers and the analysts. The respondents were likewise assured that no information that discloses their identity will be released or published without their consent, except when extremely necessary.

Results and Discussions

This chapter provides a concise overview of the study's discoveries stemming from thorough data collection, rigorous analysis, and insightful interpretation. Following this, key conclusions were drawn from the initial analytical phase, thereby offering valuable insights.

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Student Engagement in Math PBL via Six Essential Factors

Table 1
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions

Items	Mean	Interpretation
1. I understand the driving question and make small changes to improve the quality of my project.	4.12	Great Extent
2. I organize and go beyond fact-finding solutions to find the answers to my driving questions.	3.80	Great Extent
3. I put effort into organizing central problems or questions at the appropriate Extent of challenge.	4.05	Great Extent
4. I enjoy open-ended questions because they provide multiple possible answers.	3.74	Great Extent
5. I am aware of our student-friendly language and clear criteria planners and rubrics of the project.	4.41	Great Extent
6. I asked questions during class and sought answers.	3.62	Great Extent
7. I contributed to class discussions based on the driving questions given.	3.66	Great Extent
Overall Mean	**3.91**	**Great Extent**

Table 1 presents the level of student engagement in PBL approach for mathematics, specifically through driving questions, showcasing an overall mean score of 3.91, interpreted to mean great extent (GE). In summary, the overall positive mean score suggests that students are actively involved in the PBL approach, particularly in addressing driving questions. Krall et al.'s (2022) research outcomes indicate that involving students in the creation of driving questions positively impacts their understanding of lessons and enhances their participation in project-based learning. This collaborative approach fosters a deeper comprehension of the subject matter and contributes to an overall improvement in student engagement throughout the learning process.

Table 2
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Sustained Inquiry Questions

Items	Mean	Interpretation
1. I am actively involved in an in-depth process where I can generate questions, find and use resources, ask further questions, and develop my answers.	3.78	Great Extent
2. I exert effort to pose questions and gather academically rigorous and challenging data.	3.66	Great Extent
3. I see to it that I can share, interpret data, and develop and evaluate solutions to the problem of the project.	3.88	Great Extent
4. I can provide the required evidence for answers and ask further questions to build a good outcome for my project.	4.13	Great Extent
5. I spend considerable time organizing and creating student-generated questions throughout the project.	3.68	Great Extent

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6. I see to it that I will help formulate and generate student-generated questions throughout the project.	3.73	Great Extent
7. I undertake inquiry rigorously because it provides multiple opportunities and needs for Great-Extent questioning.	3.61	Great Extent
Overall Mean	**3.78**	**Great Extent**

Table 2 illustrates the degree of student involvement in the PBL approach for mathematics, specifically focusing on sustained inquiry, presenting an overall mean score of 3.78, still interpreted to mean GE. The positive overall mean score for this table suggests that students are actively and rigorously involved in sustained inquiry processes, leveraging it as a valuable tool for enhancing their learning experiences and project outcomes. Cruz et al. (2022) corroborate this result with their report that, in PBL, students actively contribute to formulating and generating sustained-inquiry questions throughout the project. The results emphasize the pivotal role of students in shaping and answering their own questions, highlighting a high level of engagement, especially in the creation of student-generated questions.

Table 3
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Authenticity

Items	Mean	Interpretation
1. I enjoy taking part in an authentic and meaningful role in the classroom such as acting as an engineer, mathematician, etc.	3.67	Great Extent
2. I want to engage in real work, real problems, and real questions in the classroom like building a castle project by calculating the volume of the entire castle.	3.86	Great Extent
3. I can produce an authentic scientific investigation with real scientific findings using the given formula for my calculations.	3.83	Great Extent
4. I allow myself to personally connect to the project by creating and using my personal experiences to build my own beliefs and values like designing my own project preference (Ex. Castle Project).	3.83	Great Extent
5. I can create products that have positive real impacts on my school and real communities.	3.72	Great Extent
6. I see to it that I can connect to my classmate's concerns, interests, and identities in the classroom.	3.76	Great Extent
7. I follow instructions on putting out a real project or product.	4.19	Great Extent
Overall Mean	**3.84**	**Great Extent**

Table 3 analyzes the extent of student engagement within the PBL framework for mathematics, specifically emphasizing authenticity, with an overall mean score of 3.84, interpreted to mean GE. Overall, the findings showed a generally consistent level of engagement across various aspects of authenticity. Nicholas and Scribner (2021) examined a high school STEM project in the Midwestern US that emphasized authenticity by involving local professionals as PBL designers and facilitators. The study explored how students, teachers, and volunteers experienced this authenticity using a comprehensive framework suited to Math in STEM PBL. By assuming real-world roles, students improved retention through memorable experiences, though there remains potential to enhance enjoyment in these authentic roles.

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Table 4

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Collaboration

Items	Mean	Interpretation
1. I can be counted on to join and stay interested in a project, even if it moves away from what I am interested in.	3.93	Great Extent
2. I participate in group problem-solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.	3.93	Great Extent
3. I am a good representative of the team and the work of my group members when I am in other settings.	3.95	Great Extent
4. I know how to gauge my impact on the group and am routinely aware of team dynamics.	3.99	Great Extent
5. I freely share ideas, information, and resources.	4.01	Great Extent
6. I enjoy taking significant responsibility and working collaboratively with my teachers and group mates.	3.94	Great Extent
7. I work with my group mates by helping each other to grow together in a collaborative environment.	3.86	Great Extent
Overall Mean	**3.94**	**Great Extent**

Table 6 provides an insightful view into how students engage with the mathematics PBL framework, focusing on collaboration. The overall mean score stands at an encouraging 3.94, still interpreted to mean GE. In summary, the high level of student engagement in collaboration within the PBL framework suggests that students, on average, actively participate and value collaborative efforts in their learning experiences. Riswaari and Bintoro (2020) highlighted the positive impact of the PBL model on student engagement in mathematics, emphasizing the importance of active collaboration. This goes beyond passive observation, requiring both psychological and physical participation. They stressed the need for students to understand both theoretical and practical aspects of learning, with increased engagement in applying knowledge to real-life scenarios leading to more effective learning outcomes.

Table 5

Student Engagement in PBL Approach in Mathematics in the PBL Essential of 21st Century Skills

Items	Mean	Interpretation
1. I prefer solving real-world challenges that draw connections between modern skills and the changing world around us.	3.87	Great Extent
2. I feel comfortable applying learning skills that focus on areas like critical thinking and creativity.	3.97	Great Extent
3. I believe that learning how to think critically will improve my problem-solving, reasoning, and decision-making skills.	4.12	Great Extent
4. I can network more effectively and form stronger connections with peers if I have strong social skills.	3.98	Great Extent
5. I am aware that I need to update my digital literacy to expand my network and possibly create new opportunities.	3.92	Great Extent
6. I can make choices and judgments that help people see things more clearly and lead to better answers.	3.96	Great Extent

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7. I can reflect critically on learning experiences and processes.	4.07	Great Extent
Overall Mean	**3.98**	**Great Extent**

Table 5 offers valuable insights into how students engage with the PBL framework in mathematics, focusing specifically on their 21st Century Skills. The overall mean score is an encouraging 3.98, still interpreted to mean GE. Rehman et al. (2023) reported the importance of equipping students with twenty-first-century skills, especially those pertaining to real-life problem-solving, in order to maintain competitiveness within the contemporary global economy. Their study focused on implementing PBL as an instructional tool for teaching mathematics at the primary level. Employing a convergent mixed-methods approach, the research aimed to assess the impact of the PBL approach on enhancing students' twenty-first-century skills, including collaborative abilities, problem-solving aptitude, and critical thinking proficiency.

Table 6

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Public Product

Items	Mean	Interpretation
1. I feel supported with all the knowledge required to complete the task of my work project or my public product.	4.10	Great Extent
2. Presenting my public product to the "real world" and having them critique my work is a proud moment.	3.83	Great Extent
3. I feel satisfied if my products will be presented for viewing or will go public.	3.72	Great Extent
4. I feel that increasing my Extent of accountability and engagement will ensure the completion of my project.	3.95	Great Extent
5. I thrive off of anything video-related projects such as vlogging, making documentaries, creating video promotions, and music videos.	3.56	Great Extent
6. I am open and enjoy listening to any project design and management that suggests an improvement for my product.	3.90	Great Extent
7. I believe that comments and suggestions about my project make learning stick at the end of my work and help me think about what's working well and what's not during the process.	3.99	Great Extent
Overall Mean	**3.86**	**Great Extent**

Table 6 offers valuable insights into how students engage with the PBL framework in mathematics, focusing specifically on their Public Products. The overall mean score is an encouraging 3.86, again interpreted to mean GE. All in all, the data reveals an overall positive level of student engagement in creating and presenting public products within the PBL framework, as evidenced by the 'great extent' category of the overall mean score.

To Čubela et al. (2023), project-based learning environments exhibit distinct characteristics, particularly in the aspect of students generating tangible products as responses to guiding questions. These products, known as shared artifacts, serve as publicly accessible external representations of the class's collective learning. Although problem-based learning is not the sole approach for tackling ill-structured and complex problems in teaching, empirical evidence suggests its superiority over conventional classroom teaching in terms of long-term retention, skill development, and overall satisfaction of both students and teachers.

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Student Engagement in PBL Approach in Mathematics via Six PBL Essentials when Grouped by Demographics

Table 7
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions when Grouped by Sex

Items	Male		Female	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I understand the driving question and make small changes to improve the quality of my project.	4.19	Great Extent	4.07	Great Extent
2. I organize and go beyond fact-finding solutions to find the answers to my driving questions.	3.80	Great Extent	3.81	Great Extent
3. I put effort into organizing central problems or questions at the appropriate Extent of challenge.	3.98	Great Extent	4.11	Great Extent
4. I enjoy open-ended questions because they provide multiple possible answers.	3.79	Great Extent	3.70	Great Extent
5. I am aware of our student-friendly language and clear criteria planners and rubrics of the project.	4.41	Great Extent	4.42	Great Extent
6. I asked questions during class and sought answers.	3.70	Great Extent	3.56	Great Extent
7. I contributed to class discussions based on the driving questions given.	3.70	Great Extent	3.63	Great Extent
Overall Mean	**3.94**	**Great Extent**	**3.90**	**Great Extent**

Table 7 provides valuable insights into how students, categorized by sex, engage with the PBL framework in mathematics, particularly through driving questions. The overall mean score for male students is 3.70, firmly within the GE category, while the overall mean score for female students is 3.56, also falling within the GE category. In summary, the overall mean scores for both male and female students suggest a generally positive level of engagement in addressing driving questions within the PBL framework for both groups.

Sintema and Jita (2022) observed that both males and females demonstrated a positive inclination toward engaging with driving questions within the PBL framework. In contrast, Mejía-Rodríguez et al. (2021) asserted that, in numerous nations, including Zambia, boys typically display higher proficiency in solving mathematical problems across various mathematical topics. Which starts with understanding the given questions in a problem. Addressing the gender disparity in mathematical performance among students, Dai et al. (2022) presented empirical findings indicating that the integration of games and narratives that encourage students to create meaningful driving questions into mathematical activities tends to facilitate the development of girls' problem-solving skills in mathematics.

Table 8
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Sustained Inquiry when Grouped by Sex

Items	Male	Female

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	Mean	Interpretation	Mean	Interpretation
1. I am actively involved in an in-depth process where I can generate questions, find and use resources, ask further questions, and develop my answers.	3.84	Great Extent	3.73	Great Extent
2. I exert effort to pose questions and gather academically rigorous and challenging data.	3.67	Great Extent	3.65	Great Extent
3. I see to it that I can share, interpret data, and develop and evaluate solutions to the problem of the project.	3.80	Great Extent	3.95	Great Extent
4. I can provide the required evidence for answers and ask further questions to build a good outcome for my project.	4.15	Great Extent	4.12	Great Extent
5. I spend considerable time organizing and creating student-generated questions throughout the project.	3.65	Great Extent	3.70	Great Extent
6. I see to it that I will help formulate and generate student-generated questions throughout the project.	3.74	Great Extent	3.72	Great Extent
7. I undertake inquiry rigorously because it provides multiple opportunities and needs for Great-Extent questioning.	3.52	Great Extent	3.67	Great Extent
Overall Mean	**3.77**	**Great Extent**	**3.79**	**Great Extent**

Table 8 provides insights into how students, grouped by sex, engage with the PBL framework in mathematics, specifically through Sustained Inquiry. The overall mean score for male students is 3.77, placing them within the GE category. Similarly, the overall mean score for female students is 3.79, also falling within the GE category. The overall mean scores for both groups indicate a generally positive level of engagement in Sustained Inquiry within the PBL framework. Jusra and Ramadhani (2022) highlighted that gender exerts an influence on sustained inquiry and the self-efficacy of students in mathematical problem-solving. The research indicated that students' inclination to invest effort in formulating questions and collecting academically rigorous and challenging data for their projects is affected by their gender. According to these studies, individuals, regardless of gender, who possess a heightened comprehension of the problem, demonstrate the ability to share, interpret data, and formulate and assess solutions to project-related issues tend to exhibit superior mathematical problem-solving abilities.

Table 9

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Authenticity when Grouped by Sex

Items	Male		Female	
	Mean	Interpretation	Mean	Interpretation
1. I enjoy taking part in an authentic and meaningful role in the classroom such as acting as an engineer, mathematician, etc.	3.73	Great Extent	3.63	Great Extent

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2. I want to engage in real work, real problems, and real questions in the classroom like building a castle project by calculating the volume of the entire castle.	3.90	Great Extent	3.83	Great Extent
3. I can produce an authentic scientific investigation with real scientific findings using the given formula for my calculations.	3.88	Great Extent	3.79	Great Extent
4. I allow myself to personally connect to the project by creating and using my personal experiences to build my own beliefs and values like designing my own project preference (Ex. Castle Project).	3.85	Great Extent	3.82	Great Extent
5. I can create products that have positive impacts on my school and real communities.	3.72	Great Extent	3.72	Great Extent
6. I see to it that I can connect to my classmate's concerns, interests, and identities in the classroom.	3.72	Great Extent	3.80	Great Extent
7. I follow instructions on putting out a real project or product.	4.24	Great Extent	4.14	Great Extent
Overall Mean	**3.86**	**Great Extent**	**3.82**	**Great Extent**

Table 9 offers intriguing insights into the engagement of students, categorized by gender, with the PBL framework in mathematics focusing on authenticity. Both male and female students got mean scores of 3.86 and 3.82, respectively, all categorized as GE. The overall mean scores for males and females are quite close, indicating a consistent level of engagement between the two genders, particularly in terms of authenticity. Riswari et al. (2020) placed emphasis on the significance of authenticity in educational settings, particularly in fostering student engagement and learning and preparing them for prospective job markets, notably in science and technology. The collaborative nature of group work within the PBL framework is identified as a catalyst for optimizing students' problem-solving skills. Through this process, students have the opportunity to empower, refine, test, and cultivate their cognitive abilities continuously.

Table 10
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Collaboration when Grouped by Sex

Items	Male		Female	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I can be counted on to join and stay interested in a project, even if it moves away from what I'm interested in.	3.94	Great Extent	3.92	Great Extent
2. I participate in group problem-solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.	3.87	Great Extent	3.97	Great Extent

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3. I am a good representative of the team and the work of my group members when I am in other settings.	3.94	Great Extent	3.96	Great Extent
4. I know how to gauge my impact on the group and am routinely aware of team dynamics.	3.99	Great Extent	3.99	Great Extent
5. I freely share ideas, information, and resources.	3.99	Great Extent	4.03	Great Extent
6. I enjoy taking significant responsibility and working collaboratively with my teachers and group mates.	3.99	Great Extent	3.90	Great Extent
7. I work with my group mates by helping each other to grow together in a collaborative environment.	3.86	Great Extent	3.87	Great Extent
Overall Mean	**3.94**	**Great Extent**	**3.95**	**Great Extent**

Table 10 offers a reflective glimpse into how students actively engage with the mathematics PBL framework, specifically focusing on the critical aspect of collaboration. The males got an overall mean score of 3.94, while the females got a slightly higher mean score of 3.95. The data implies a positive and robust engagement of both male and female students with the Collaboration aspect of the PBL framework in mathematics. Riswaari et al. (2020) studied 60 students, focusing on male students who excelled in open collaboration and evaluating their group impact, showing strong team dynamics and responsibility. The study highlights that all students, regardless of gender, benefit from understanding both the practical and theoretical aspects of their studies. Reflecting on real-life applications deepens engagement and enhances the learning experience. Both male and female students actively participate in collaborative learning, working in small groups to solve problems and achieve goals, fostering problem-solving skills through collective inquiry and solution-seeking.

Table 11

Student Engagement in PBL Approach in Mathematics in the PBL Essential of 21st Century Skills when Grouped by Sex

Items	**Male**		**Female**	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I prefer solving real-world challenges that draw connections between modern skills and the changing world around us.	3.87	Great Extent	3.87	Great Extent
2. I feel comfortable applying learning skills that focus on areas like critical thinking and creativity.	3.83	Great Extent	4.08	Great Extent
3. I believe that learning how to think critically will improve my problem-solving, reasoning, and decision-making skills.	4.01	Great Extent	4.19	Great Extent
4. I can network more effectively and form stronger connections with peers if I have strong social skills.	3.83	Great Extent	4.11	Great Extent

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5. I am aware that I need to update my digital literacy to expand my network and possibly create new opportunities.	3.84	Great Extent	3.98	Great Extent
6. I can make choices and judgments that help people see things more clearly and lead to better answers.	3.88	Great Extent	4.03	Great Extent
7. I can reflect critically on learning experiences and processes.	3.99	Great Extent	4.13	Great Extent
Overall Mean	**3.89**	**Great Extent**	**4.05**	**Great Extent**

Table 11 offers insights into student engagement with the PBL framework in mathematics, emphasizing 21st Century Skills. The aggregate mean score for males is 3.89, and for females, it is 4.05. Though slightly different, both scores fall within the GE range. Overall, the data indicates that students, irrespective of gender, generally embrace the development of 21st Century Skills within the PBL framework in mathematics. Humairah's (2021) study found that female students showed higher engagement and stronger 21st Century Skills in problem-solving compared to males, though gender differences were not statistically significant for other variables. In mixed-sex schools, no significant gender variations were observed, indicating that both male and female students are equally adept at applying learning skills, building social connections, and addressing real-world challenges using contemporary skills.

Table 12

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Public Product when Grouped by Sex

Items	Male		Female	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I feel supported with all the knowledge required to complete the task of my work project or my public product.	4.13	Great Extent	4.07	Great Extent
2. Presenting my public product to the “real world” and having them critique my work is a proud moment.	3.93	Great Extent	3.75	Great Extent
3. I feel satisfied if my products will be presented for viewing or will go public.	3.63	Great Extent	3.79	Great Extent
4. I feel that increasing my Extent of accountability and engagement will ensure the completion of my project.	3.83	Great Extent	4.04	Great Extent
5. I thrive off of anything video-related projects such as vlogging, making documentaries, creating video promotions, and music videos.	3.47	Moderate Extent	3.63	Great Extent
6. I am open and enjoy listening to any project design and management that suggests an improvement for my product.	3.85	Great Extent	3.95	Great Extent
7. I believe that comments and suggestions about my project make	3.92	Great Extent	4.05	Great Extent

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learning stick at the end of my work and help me think about what's working well and what's not during the process.				
Overall Mean	**3.82**	**Great Extent**	**3.90**	**Great Extent**

Table 12 offers insights into sex-specific engagement with the PBL framework in mathematics, focusing on the public product. Male students achieve an overall mean score of 3.82 (GE), and female students score 3.90 (GE). The data shows that both genders demonstrate a positive involvement in the public product dimension of PBL in mathematics. Umar and Ko (2022) reported that both genders exhibit active engagement in the public product dimension of PBL within the realm of mathematics. This study explored the repercussions of fostering a shared understanding of student learning by showcasing their lesson output as a product and evaluating its effectiveness for students and classroom methodologies, incorporating contemporary elements that bridge digital learning. The application of the public product, as demonstrated in their learning experiences, serves as a means for students to apply acquired knowledge to contexts beyond themselves. The significance lies in the product's meaningful impact on someone outside the PBL group, extending beyond the immediate participants.

Table 13

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions when Grouped by Student Working Status

Items	Working		Not Working	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I understand the driving question and make small changes to improve the quality of my project.	4.18	Great Extent	4.09	Great Extent
2. I organize and go beyond fact-finding solutions to find the answers to my driving questions.	3.92	Great Extent	3.75	Great Extent
3. I put effort into organizing central problems or questions at the appropriate Extent of challenge.	4.00	Great Extent	4.07	Great Extent
4. I enjoy open-ended questions because they provide multiple possible answers.	3.88	Great Extent	3.67	Great Extent
5. I am aware of our student-friendly language and clear criteria planners and rubrics of the project.	4.38	Great Extent	4.43	Great Extent
6. I asked questions during class and sought answers.	3.77	Great Extent	3.54	Great Extent
7. I contributed to class discussions based on the driving questions given.	3.77	Great Extent	3.60	Great Extent
Overall Mean	**3.99**	**Great Extent**	**3.88**	**Great Extent**

Table 13 provides valuable insights into how students, categorized by the students' working status, engage with the PBL framework in mathematics, particularly through driving questions. The overall mean score for working students is 3.99, while the overall mean score for non-working students is 3.88, still falling within the GE category. Mercer and Dörnyei (2020) emphasized the crucial role of interpersonal relationships in various aspects of learning. They underscored that positive connections with others

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significantly enhance individuals' enthusiasm for learning, contributing to sustained learning success and bolstering self-confidence. Notably, the relationships between students and teachers, along with students' perceptions of their educators, were highlighted as influential factors shaping students' engagement in academic pursuits.

Table 14
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Sustained Inquiry when Grouped by Student Working Status

Items	Working		Not Working	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I am actively involved in an in-depth process where I can generate questions, find and use resources, ask further questions, and develop my answers.	3.80	Great Extent	3.77	Great Extent
2. I exert effort to pose questions and gather academically rigorous and challenging data.	3.68	Great Extent	3.65	Great Extent
3. I see to it that I can share, interpret data, and develop and evaluate solutions to the problem of the project.	3.83	Great Extent	3.91	Great Extent
4. I can provide the required evidence for answers and ask further questions to build a good outcome for my project.	4.12	Great Extent	4.13	Great Extent
5. I spend considerable time organizing and creating student-generated questions throughout the project.	3.80	Great Extent	3.62	Great Extent
6. I see to it that I will help formulate and generate student-generated questions throughout the project.	3.80	Great Extent	3.69	Great Extent
7. I undertake inquiry rigorously because it provides multiple opportunities and needs for Great-Extent questioning.	3.74	Great Extent	3.54	Great Extent
Overall Mean	**3.82**	**Great Extent**	**3.76**	**Great Extent**

Table 14 examines how students, based on their working status, participate in the PBL framework in mathematics, focusing on sustained inquiry. Working students scored an overall mean of 3.82, and non-working students scored 3.76, both falling within the GE category. The overall engagement in Table 14 depicts is high level of positive engagement with sustained inquiry in PBL framework for both working and non-working students, especially on the ability to provide necessary evidence for their responses and pose additional inquiries, enhancing the quality of project outcomes (item No. 4). Despite lower scores on specific items, both working and non-working categories consistently fall within the 'Great Extent' category, suggesting a generally high level of sustained inquiry engagement across the board. Lastly, the differences in mean scores between working and non-working categories are relatively small, indicating similar levels of engagement overall.

Mercer and Dörnyei (2020) emphasized the noteworthy level of positive engagement observed within the PBL framework, particularly regarding sustained inquiry in math classrooms. In math classrooms, sustained inquiry through PBL encourages students to actively seek solutions to real-world problems or complex mathematical challenges. By engaging in authentic problem-solving processes,

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students develop a deeper understanding of mathematical concepts and principles. This hands-on approach allows them to apply theoretical knowledge to practical situations, making learning more meaningful and relevant.

Table 15

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Authenticity when Grouped by Student Working Status

Items	Working		Not Working	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I enjoy taking part in an authentic and meaningful role in the classroom such as acting as an engineer, mathematician, etc.	3.69	Great Extent	3.66	Great Extent
2. I want to engage in real work, real problems, and real questions in the classroom like building a castle project by calculating the volume of the entire castle.	3.91	Great Extent	3.84	Great Extent
3. I can produce an authentic scientific investigation with real scientific findings using the given formula for my calculations.	3.83	Great Extent	3.83	Great Extent
4. I allow myself to personally connect to the project by creating and using my personal experiences to build my own beliefs and values like designing my own project preference (Ex. Castle Project).	3.85	Great Extent	3.83	Great Extent
5. I can create products that have positive impacts on my school and real communities.	3.77	Great Extent	3.69	Great Extent
6. I see to it that I can connect to my classmate's concerns, interests, and identities in the classroom.	3.75	Great Extent	3.77	Great Extent
7. I follow instructions on putting out a real project or product.	4.17	Great Extent	4.19	Great Extent
Overall Mean	**3.85**	**Great Extent**	**3.83**	**Great Extent**

Table 15 examines student engagement with the PBL framework in mathematics, specifically in authenticity, based on working status. The overall mean score for working students is 3.85, while for non-working students it is 3.83. The overall mean scores for working (3.85) and non-working (3.83) students fall within the GE category, indicating strong engagement. De Vivo (2022) highlighted key characteristics of successful PBL programs, emphasizing that lessons should be driven by authentic student inquiries that lead to meaningful driving questions. This approach allows students to explore issues beyond the classroom, engaging with their community and the wider world. The focus on authenticity is reflected in the strong involvement of both employed and unemployed students, demonstrating a positive response to

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real-world learning experiences. Ensuring the project's authenticity and meaningful output is crucial for maintaining student engagement and investment in their learning.

Table 16
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Collaboration when Grouped by Student Working Status

Items	Working		Not Working	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I can be counted on to join and stay interested in a project, even if it moves away from what I'm interested in.	3.95	Great Extent	3.92	Great Extent
2. I participate in group problem-solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.	3.94	Great Extent	3.93	Great Extent
3. I am a good representative of the team and the work of my group members when I am in other settings.	3.95	Great Extent	3.95	Great Extent
4. I know how to gauge my impact on the group and am routinely aware of team dynamics.	3.98	Great Extent	3.99	Great Extent
5. I freely share ideas, information, and resources.	3.94	Great Extent	4.04	Great Extent
6. I enjoy taking significant responsibility and working collaboratively with my teachers and group mates.	3.94	Great Extent	3.94	Great Extent
7. I work with my group mates by helping each other to grow together in a collaborative environment.	3.91	Great Extent	3.84	Great Extent
Overall Mean	**3.95**	**Great Extent**	**3.94**	**Great Extent**

Table 16 analyzes student engagement in the mathematics PBL framework, emphasizing student collaboration when grouped by working status. The overall mean score is 3.95 for working students and slightly lower at 3.94 for non-working students. The data indicates a positive and effective collaboration within the PBL framework, with nuanced variations in specific aspects between working and non-working students. Almulla's (2020) study emphasized the importance of responsiveness and collaboration in education. Learning becomes a collaborative process where students and teachers negotiate ideas, allowing teachers to share expertise across subjects. This teamwork fosters a shared discovery process, exploring topics from diverse perspectives. Collaboration between teachers also leads to better outcomes, as peer support enhances overall performance.

Table 17
Student Engagement in PBL Approach in Mathematics in the PBL Essential of 21st Century Skills when Grouped by Student Working Status

Items	Working	Not Working

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	Mean	Interpretation	Mean	Interpretation
1. I prefer solving real-world challenges that draw connections between modern skills and the changing world around us.	3.78	Great Extent	3.91	Great Extent
2. I feel comfortable applying learning skills that focus on areas like critical thinking and creativity.	3.97	Great Extent	3.97	Great Extent
3. I believe that learning how to think critically will improve my problem-solving, reasoning, and decision-making skills.	4.05	Great Extent	4.15	Great Extent
4. I can network more effectively and form stronger connections with peers if I have strong social skills.	3.97	Great Extent	3.99	Great Extent
5. I am aware that I need to update my digital literacy to expand my network and possibly create new opportunities.	3.92	Great Extent	3.92	Great Extent
6. I can make choices and judgments that help people see things more clearly and lead to better answers.	3.98	Great Extent	3.96	Great Extent
7. I can reflect critically on learning experiences and processes.	4.02	Great Extent	4.10	Great Extent
Overall Mean	**3.95**	**Great Extent**	**4.00**	**Great Extent**

Table 17 provides insight into student engagement with the mathematics PBL framework, emphasizing 21st Century Skills when grouped by working status. The overall mean score is 3.95 for working students and slightly higher at 4.00 for non-working students. The high overall mean scores imply a positive orientation towards 21st Century Skills development in the PBL framework for both working and non-working students. Yang et al. (2021) reported how PBL has gained global recognition as a viable alternative to traditional teacher-centered education, prioritizing hands-on, collaborative approaches while integrating 21st-century skills and inquiry-based learning activities. Previous research suggests that PBL effectively enhances student learning, engagement, and academic performance across various disciplines, such as mathematics and science. For instance, Paryanto et al. (2023) demonstrated that PBL positively impacted student achievement and attitudes toward learning in engineering education.

Table 18
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Public Product when Grouped by Student Working Status

Items	Working		Not Working	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I feel supported with all the knowledge required to complete the task of my work project or my public product.	4.09	Great Extent	4.10	Great Extent
2. Presenting my public product to the “real world” and having them critique my work is a proud moment.	3.95	Great Extent	3.77	Great Extent

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3. I feel satisfied if my products will be presented for viewing or will go public.	3.86	Great Extent	3.65	Great Extent
4. I feel that increasing my Extent of accountability and engagement will ensure the completion of my project.	3.86	Great Extent	3.99	Great Extent
5. I thrive off of anything video-related projects such as vlogging, making documentaries, creating video promotions, and music videos.	3.49	Great Extent	3.59	Great Extent
6. I am open and enjoy listening to any project design and management that suggests an improvement for my product.	4.03	Great Extent	3.84	Great Extent
7. I believe that comments and suggestions about my project make learning stick at the end of my work and help me think about what's working well and what's not during the process.	3.95	Great Extent	4.01	Great Extent
Overall Mean	**3.89**	**Great Extent**	**3.85**	**Great Extent**

Table 18 offers a glimpse into how students, grouped according to their working status, actively engage with the mathematics PBL framework, focusing specifically on their Public Products. The overall mean score for the working category is 3.89 and 3.85 for the non-working category. The data implies positive engagement and a strong commitment to public products within the PBL framework for both working and non-working students.

Anggito et al. (2021) support this study, indicating that creating public products such as video PBL stimulates students' eagerness to learn. Likewise, Lugiati (2020) highlighted how video PBL enhances student learning outcomes. Videos condense lengthy events into concise, dense presentations aided by visual and auditory elements that enable revisiting and deeper understanding of the content. Moreover, the application of video-assisted PBL extends beyond high schools to elementary levels, aiming to boost artistic creativity among young learners (Handayani & Dian, 2021). Recognizing the need for improved student learning outcomes and enhanced critical thinking skills, project-based learning emerges as a promising approach. PBL fosters active engagement and collaborative problem-solving, encouraging higher-order thinking skills.

Table 19

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions when Grouped by Parents' Education

Items	LEA		HEA	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I understand the driving question and make small changes to improve the quality of my project.	4.06	Great Extent	4.19	Great Extent
2. I organize and go beyond fact-finding solutions to find the answers to my driving questions.	3.69	Great Extent	3.93	Great Extent

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3. I put effort into organizing central problems or questions at the appropriate Extent of challenge.	3.97	Great Extent	4.13	Great Extent
4. I enjoy open-ended questions because they provide multiple possible answers.	3.74	Great Extent	3.74	Great Extent
5. I am aware of our student-friendly language and clear criteria planners and rubrics of the project.	4.27	Great Extent	4.56	Very Great Extent
6. I asked questions during class and sought answers.	3.45	Moderate Extent	3.79	Great Extent
7. I contributed to class discussions based on the driving questions given.	3.57	Great Extent	3.75	Great Extent
Overall Mean	**3.82**	**Great Extent**	**4.01**	**Great Extent**

Table 19 provides valuable insights into how students, categorized by their parents' education, engage with the PBL framework in mathematics, particularly through driving questions. The overall mean score for the lower educational attainment (LEA) group is 3.82, while the overall mean score for the higher educational attainment (HEA) group is 4.01, falling within the 'great extent' category. In summary, the data suggests that students with parents having HEA, on average, demonstrate a slightly elevated level of engagement with the PBL framework in mathematics. Amerstorfer and Von Münster-Kistner (2021) emphasize various strategies that teachers can employ to enhance students' academic engagement. The study reveals that academic engagement is closely intertwined with affective factors that impact students both individually (such as motivation and enjoyment) and as part of a team (including team spirit and concerns about social status). Moreover, parental support at home also plays a significant role in influencing student engagement.

Table 20

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Sustained Inquiry when Grouped by Parents' Education

Items	**LEA**		**HEA**	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I am actively involved in an in-depth process where I can generate questions, find and use resources, ask further questions, and develop my answers.	3.63	Great Extent	3.94	Great Extent
2. I exert effort to pose questions and gather academically rigorous and challenging data.	3.53	Great Extent	3.79	Great Extent
3. I see to it that I can share, interpret data, and develop and evaluate solutions to the problem of the project.	3.73	Great Extent	4.05	Great Extent
4. I can provide the required evidence for answers and ask further questions to build a good outcome for my project.	3.98	Great Extent	4.29	Great Extent
5. I spend considerable time organizing and creating studentgenerated questions throughout the project.	3.54	Great Extent	3.82	Great Extent

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6. I see to it that I will help formulate and generate student-generated questions throughout the project.	3.55	Great Extent	3.92	Great Extent
7. I undertake inquiry rigorously because it provides multiple opportunities and needs for Great-Extent questioning.	3.47	Moderate Extent	3.75	Great Extent
Overall Mean	**3.63**	**Great Extent**	**3.94**	**Great Extent**

Table 20 provides valuable insights into how students, grouped by their parents' education, engage with the PBL framework in mathematics, specifically through sustained inquiry. The overall mean score for the LEA group is 3.63. Similarly, the overall mean score for the HEA group is 3.94. In their study, Žerovnik and Šerbec (2021) underscored the critical elements of successful PBL implementation, emphasizing the importance of adhering to key project design principles. These include initiating projects with challenging problems or questions formulated by students or groups and providing ample time for sustained inquiry, during which students can inquire, explore, research, and engage with materials meaningfully.

It is emphasized that while all PBL teachers should incorporate inquiry-based methods into their teaching, the implementation may vary across different grade levels, subject areas, and types of projects. Engaging in sustained inquiry enables students to interact with the world through a lens of curiosity. Through inquiry-based projects, students develop the ability to pose meaningful questions and the agency to effectively seek answers to those questions. Moreover, sustained inquiry facilitates the retention of content and skills, as students actively seek and co-construct knowledge, rather than passively receiving it.

Table 21
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Authenticity Questions when Grouped by Parents' Education

Items	**LEA**		**HEA**	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I enjoy taking part in an authentic and meaningful role in the classroom, such as acting as an engineer, mathematician, etc.	3.53	Great Extent	3.82	Great Extent
2. I want to engage in real work, real problems, and real questions in the classroom, like building a castle project by calculating the volume of the entire castle.	3.72	Great Extent	4.01	Great Extent
3. I can produce an authentic scientific investigation with real scientific findings using the given formula for my calculations.	3.62	Great Extent	4.05	Great Extent
4. I allow myself to personally connect to the project by creating and using my personal experiences to build my own beliefs and values like designing my project preference (Ex. Castle Project).	3.60	Great Extent	4.08	Great Extent

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5. I can create products that have positive real impacts on my school and real communities.	3.49	Great Extent	3.96	Great Extent
6. I see to it that I can connect to my classmate's concerns, interests, and identities in the classroom.	3.52	Great Extent	4.02	Great Extent
7. I follow instructions on putting out a real project or product.	3.92	Great Extent	4.46	Great Extent
Overall Mean	**3.63**	**Great Extent**	**4.06**	**Great Extent**

Table 21 offers insights into how students, grouped by their parents' education, engage with the PBL framework in mathematics, focusing on authenticity. The overall mean score for the LEA group is 3.63 and 4.06 for the HEA group, placing them both within the GE category. These figures indicate a generally consistent and positive engagement with authenticity in the PBL framework for both groups. MckKibben and Murphy (2021) conducted a quasi-experimental study to examine the impact of project authenticity in PBL on student achievement. Their findings revealed that authenticity significantly contributed to students' educational progress. When projects are designed with authenticity as a focal point, students become deeply engaged in learning with a sense of purpose.

Table 22

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Collaboration when Grouped by Parents' Education

Items	LEA		HEA	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I can be counted on to join and stay interested in a project, even if it moves away from what I'm interested in.	3.73	Great Extent	4.14	Great Extent
2. I participate in group problem-solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.	3.74	Great Extent	4.13	Great Extent
3. I am a good representative of the team and the work of my group members when I am in other settings.	3.79	Great Extent	4.11	Great Extent
4. I know how to gauge my impact on the group and am routinely aware of team dynamics.	3.77	Great Extent	4.22	Great Extent
5. I freely share ideas, information, and resources.	3.82	Great Extent	4.21	Great Extent
6. I enjoy taking significant responsibility and working collaboratively with my teachers and group mates.	3.70	Great Extent	4.20	Great Extent
7. I work with my group mates by helping each other to grow together in a collaborative environment.	3.65	Great Extent	4.09	Great Extent
Overall Mean	**3.74**	**Great Extent**	**4.16**	**Great Extent**

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Table 22 offers insights into how students, grouped by their parents' education, engage with the PBL framework in mathematics, looking closely at the critical aspect of collaboration. The overall mean score for the LEA group is 3.74 and 4.16 for the HEA group, placing them both within the GE category. Overall, results from both groups show that students, regardless of their parents' education, generally engage well in collaboration, as indicated by the GE results for both groups. Hussein (2021) conducted a qualitative analysis of 67 reflective reports from students participating in an engineering education project-based learning assignment. The findings reveal that challenges in collaboration often stem from conflicts over priorities among students and uncertainty surrounding project assignments. While collaboration is a fundamental aspect of the PBL process, its benefits are frequently overlooked in discussions.

Table 23

Student Engagement in PBL Approach in Mathematics in the PBL Essential of 21st Century Skills Questions when Grouped by Parents' Education

Items	LEA		HEA	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I prefer solving real-world challenges that draw connections between modern skills and the changing world.	3.71	Great Extent	4.04	Great Extent
2. I feel comfortable applying learning skills that focus on areas like critical thinking and creativity.	3.74	Great Extent	4.22	Great Extent
3. I believe that learning how to think critically will improve my problem-solving, reasoning, and decision-making skills.	3.85	Great Extent	4.39	Great Extent
4. I can network more effectively and form stronger connections with peers if I have strong social skills.	3.77	Great Extent	4.21	Great Extent
5. I am aware that I need to update my digital literacy to expand my network and possibly create new opportunities.	3.82	Great Extent	4.02	Great Extent
6. I can make choices and judgments that help people see things more clearly and lead to better answers.	3.76	Great Extent	4.18	Great Extent
7. I can reflect critically on learning experiences and processes.	3.82	Great Extent	4.33	Great Extent
Overall Mean	**3.78**	**Great Extent**	**4.20**	**Great Extent**

Table 23 offers valuable insights into how students engage with the PBL framework in mathematics, focusing specifically on their 21st Century Skills when grouped according to their parents' education. The overall mean score for the LEA group is an encouraging 3.78, while the overall mean score for the HEA group is a whopping 4.20. Students exhibit robust engagement with 21st Century Skills in the PBL framework in mathematics, with their overall mean scores falling within the GE category. Carrió et al.'s study (2020) revealed that in interdisciplinary PBL courses, students and tutors perceived more significant improvement in 21st-century skills and found PBL more beneficial, leading to higher overall satisfaction with the course. There was a notable correlation between the acquisition of generic and 21st-century research skills and the perceived usefulness of PBL, especially in terms of student engagement and overall satisfaction with the learning experience.

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Table 24
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Public Product Questions when Grouped by Parents' Education

Items	LEA		HEA	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I feel supported with all the knowledge required to complete the task of my work project or my public product.	3.84	Great Extent	4.36	Great Extent
2. Presenting my public product to the "real world" and having them critique my work is a proud moment.	3.74	Great Extent	3.93	Great Extent
3. I feel satisfied if my products will be presented for viewing or will go public.	3.64	Great Extent	3.80	Great Extent
4. I feel that increasing my extent of accountability and engagement will ensure the completion of my project.	3.76	Great Extent	4.14	Great Extent
5. I thrive off of anything video-related projects such as vlogging, making documentaries, creating video promotions, and music videos.	3.45	Moderate Extent	3.67	Great Extent
6. I am open and enjoy listening to any project design and management that suggests an improvement for my product.	3.75	Great Extent	4.06	Great Extent
7. I believe that comments and suggestions about my project make learning stick at the end of my work and help me think about what's working well and what's not during the process.	3.85	Great Extent	4.14	Great Extent
Overall Mean	**3.72**	**Great Extent**	**4.02**	**Great Extent**

Table 24 offers valuable insights into how students engage with the PBL framework in mathematics, focusing specifically on the students' Public Products when grouped according to their parents' educational attainment. The overall mean score for the LEA group is 3.72 and 4.02 for the HEA group. The overall mean scores indicate positive engagement for both LEA (3.72) and HEA (4.02) groups, falling within the 'great extent' category. The result was supported by Potvin et al. (2022), focusing on the facilitative factors for scaling high-quality project-based learning (PBL), aiming to comprehend the dynamics influencing the dissemination, sustainability, and transformative potential of PBL within schools. The research delves into the engagement observed in a 9th-grade English Language Arts (ELA) study, examining the process and outcomes of deepening pedagogical practices.

Table 25
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions when Grouped by Section

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Items	Regular		Honors	
	Mean	Interpretation	Mea n	Interpretation
1. I understand the driving question and make small changes to improve the quality of my project.	4.04	Great Extent	4.23	Great Extent
2. I organize and go beyond fact-finding solutions to find the answers to my driving questions.	3.75	Great Extent	3.88	Great Extent
3. I put effort into organizing central problems or questions at the appropriate extent of the challenge.	3.88	Great Extent	4.26	Great Extent
4. I enjoy open-ended questions because they provide multiple possible answers.	3.72	Great Extent	3.76	Great Extent
5. I am aware of our student-friendly language and clear criteria planners and rubrics of the project.	4.21	Great Extent	4.67	Very Great Extent
6. I asked questions during class and sought answers.	3.54	Great Extent	3.72	Great Extent
7. I contributed to class discussions based on the driving questions given.	3.66	Great Extent	3.66	Great Extent
Overall Mean	**3.83**	**Great Extent**	**4.02**	**Great Extent**

Table 25 provides valuable insights into how students, categorized by section, engage with the PBL framework in mathematics, mainly through driving questions. The overall mean score for students in regular classes is 3.83 and 4.02 for students in honors classes. When summarized, the overall mean scores indicate a strong and positive engagement for both regular and honors classes, with both scores falling within the 'great extent' category.

Shin et al. (2021) proposed a PBL framework to develop computational thinking through modeling. At its core, it is a driving question designed around a real-world, ill-defined problem that directs students' exploration of key concepts and principles. This question structures learning activities, connects students to scientific content and practices, and ensures coherence throughout the process. Students engage with the central phenomenon, collaboratively investigate the driving question, and generate further inquiries to deepen their understanding.

Table 26

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Sustained Inquiry when Grouped by Section

Items	Regular		Honors	
	Mean	Interpretation	Mean	Interpretation
1. I am actively involved in an in-depth process where I can generate questions, find and use resources, ask further questions, and develop my answers.	3.59	Great Extent	4.02	Great Extent
2. I exert effort to pose questions and gather academically rigorous and challenging data.	3.47	Moderate Extent	3.90	Great Extent

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3. I see to it that I can share, interpret data, and develop and evaluate solutions to the problem of the project.	3.78	Great Extent	4.01	Great Extent
4. I can provide the required evidence for answers and ask further questions to build a good outcome for my project.	3.90	Great Extent	4.42	Great Extent
5. I spend considerable time organizing and creating studentgenerated questions throughout the project.	3.55	Great Extent	3.84	Great Extent
6. I see to it that I will help formulate and generate student-generated questions throughout the project.	3.63	Great Extent	3.85	Great Extent
7. I undertake inquiry rigorously because it provides multiple opportunities and needs for Great-Extent questioning.	3.41	Moderate Extent	3.85	Great Extent
Overall Mean	**3.62**	**Great Extent**	**3.99**	**Great Extent**

Table 26 highlights how students, grouped by section, engage in sustained inquiry within the PBL framework in mathematics, with average scores of 3.62 for regular students and 3.99 for honors students. This indicates active engagement by both groups. Radware Bot Manager Captcha (2020) highlights that inquiry-based methods empower students to take ownership of their learning by collaborating on projects aligned with their interests. The study aims to improve drawing proficiency through a flipped classroom strategy within PBL, using e-learning materials to support knowledge acquisition and real-world application. Students actively engage by evaluating prior knowledge, identifying learning gaps, and, with teacher guidance, creating personalized learning paths that foster creativity and innovation in solving real-world problems (Larmer, Mergendoller, & Boss, 2015).

Table 27

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Authenticity when Grouped by Section

Items	Regular		Honors	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I enjoy taking part in an authentic and meaningful role in the classroom, such as acting as an engineer, mathematician, etc.	3.45	Moderate Extent	3.95	Great Extent
2. I want to engage in real work, real problems, and fundamental questions in the classroom, like building a castle project by calculating the volume of the entire castle.	3.53	Great Extent	4.27	Great Extent
3. I can produce an authentic scientific investigation with real scientific findings using the given formula for my calculations.	3.60	Great Extent	4.11	Great Extent

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4. I allow myself to personally connect to the project by creating and using my personal experiences to build my own beliefs and values like designing my own project preference (Ex. Castle Project).	3.59	Great Extent	4.15	Great Extent
5. I can create products that have positive real impacts on my school and real communities.	3.51	Great Extent	3.98	Great Extent
6. I see to it that I can connect to my classmate's concerns, interests, and identities in the classroom.	3.47	Moderate Extent	4.14	Great Extent
7. I follow instructions on putting out a real project or product.	3.91	Great Extent	4.53	Very Great Extent
Overall Mean	**3.58**	**Great Extent**	**4.16**	**Great Extent**

Table 27 offers intriguing insights into the engagement of students, categorized by section, with the PBL framework in mathematics focusing on authenticity. Among students in regular classes, the overall mean score stands at 3.58, placing them in the 'great extent' category. Similarly, for students in honor classes, the overall mean score is 4.16, also aligning within the 'great extent' category. In summary, students in both regular and honors groups demonstrate a high level of engagement with authenticity within the PBL framework. Postlethwait (2023) explored whether high school students' attitudes toward mathematics improve in a PBL environment, focusing on engagement. The study found that students value classwork connected to their personal experiences and real-world relevance, aligning with Almarode's (2019) findings. However, it was inconclusive whether PBL participation positively impacted attitudes toward mathematics when accounting for pretest scores. Literature indicates that students benefit from projects fostering critical thinking and authentic, relatable contexts, with evidence suggesting performance improvements through this approach.

Table 28

Student Engagement in PBL Approach in Mathematics in the PBL Essential of Collaboration when Grouped by Section

Items	Regular		Honors	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I can be counted on to join and stay interested in a project, even if it moves away from what I'm interested in.	3.65	Great Extent	4.28	Great Extent
2. I participate in group problem-solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.	3.70	Great Extent	4.22	Great Extent
3. I am a good representative of the team and the work of my group members when I am in other settings.	3.77	Great Extent	4.18	Great Extent

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4. I know how to gauge my impact on the group and am routinely aware of team dynamics.	3.79	Great Extent	4.24	Great Extent
5. I freely share ideas, information, and resources.	3.76	Great Extent	4.33	Great Extent
6. I enjoy taking significant responsibility and working collaboratively with my teachers and group mates.	3.64	Great Extent	4.32	Great Extent
7. I work with my group mates by helping each other to grow together in a collaborative environment.	3.65	Great Extent	4.14	Great Extent
Overall Mean	**3.71**	**Great Extent**	**4.24**	**Great Extent**

Table 28 offers a glimpse into how students actively engage with the mathematics PBL framework, specifically focusing on the critical aspect of collaboration when grouped according to section. The overall mean score is 3.71 for the regular group and 4.24 for the honors group. The overall mean scores for both regular and honors groups indicate a high level of engagement in collaboration within the mathematics PBL framework. Rizkiyah et al.'s (2020) study yielded the following conclusions: a) The PBL model with the STEM approach positively influences students' collaborative skills, and b) The PBL model with the STEM approach positively impacts student learning outcomes if they work collaboratively among peers. Furthermore, another study posited that students thrive academically and socially in a PBL environment when they work collaboratively.

Table 29

Student Engagement in PBL Approach in Mathematics in the PBL Essential of 21st Century Skills when Grouped by Section

Items	Regular		Honors	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I prefer solving real-world challenges that draw connections between modern skills and the changing world around us.	3.65	Great Extent	4.15	Great Extent
2. I feel comfortable applying learning skills that focus on areas like critical thinking and creativity.	3.72	Great Extent	4.28	Great Extent
3. I believe that learning how to think critically will improve my problem-solving, reasoning, and decision-making skills.	3.89	Great Extent	4.40	Great Extent
4. I can network more effectively and form stronger connections with peers if I have strong social skills.	3.80	Great Extent	4.22	Great Extent
5. I am aware that I need to update my digital literacy to expand my network and possibly create new opportunities.	3.74	Great Extent	4.15	Great Extent

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6. I can make choices and judgments that help people see things more clearly and lead to better answers.	3.76	Great Extent	4.23	Great Extent
7. I can reflect critically on learning experiences and processes.	3.77	Great Extent	4.44	Great Extent
Overall Mean	**3.76**	**Great Extent**	**4.27**	**Great Extent**

Table 31 offers valuable insights into how students engage with the PBL framework in mathematics, focusing specifically on their 21st Century Skills when grouped according to section. The overall mean score for those taking regular classes is 3.76 while those taking honors classes is 4.27. Both regular and honors groups demonstrated a high level of engagement in 21st Century Skills within the PBL framework with both mean scores falling under the GE category. Permata et al. (2022) studied the impact of project-based learning (PBL) on enhancing students' 21st-century skills and fostering engagement. Survey results showed that class projects significantly improved life skills (97.1%), learning skills (95.6%), and literacy skills (88.3%), with each skill category exceeding a 50% satisfaction rate. This indicates that students gain substantial experience in these areas through classroom projects.

Table 30
Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions when Grouped by Section

Items	Regular		Honors	
	Mean	**Interpretation**	**Mean**	**Interpretation**
1. I feel supported with all the knowledge required to complete the task of my work project or my public product.	3.86	Great Extent	4.39	Great Extent
2. Presenting my public product to the "real world" and having them critique my work is a proud moment.	3.65	Great Extent	4.06	Great Extent
3. I feel satisfied if my products will be presented for viewing or will go public.	3.50	Great Extent	3.99	Great Extent
4. I feel that increasing my extent of accountability and engagement will ensure the completion of my project.	3.72	Great Extent	4.24	Great Extent
5. I thrive off of anything video-related projects such as vlogging, making documentaries, creating video promotions, and music videos.	3.50	Great Extent	3.63	Great Extent
6. I am open and enjoy listening to any project design and management that suggests an improvement for my product.	3.68	Great Extent	4.19	Great Extent
7. I believe that comments and suggestions about my project make learning stick at the end of my work and help me think about what's working well and what's not during the process.	3.77	Great Extent	4.28	Great Extent

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Overall Mean	**3.67**	**Great Extent**	**4.11**	**Great Extent**

Table 30 offers valuable insights into how students engage with the PBL framework in mathematics, focusing specifically on the students' Public Products when grouped according to section. The overall mean score for the regular group is 3.67 and 4.11 for the honors group. Junisbayeva (2020) conducted a comprehensive review of literature and analysis focusing on PBL in foreign language education and its impact on critical thinking skills. The study delved into the main concepts, key components, and the learning process inherent within PBL. Results revealed a consensus among researchers that PBL serves as a method to enhance critical thinking skills. Most scholars emphasized the importance of analytical, reflective, evaluative, and creative abilities, along with the capacity to present as a "Public Product" and have a critique of public outputs, as integral elements of the critical thinking improvement process within PBL.

Comparative Analysis in the Extent of the Student Engagement in PBL Approach in Mathematics in Six PBL Essentials and Demographics

Table 31

Difference in the Extent of Student Engagement in PBL Approach in Mathematics in the PBL Essential of Driving Questions when Grouped according to Demographics

Demographics	Category	N	Mean Rank	Mann Whitney U	p-value	*Sig. level*	Interpretation
Sex	Male	86	102.94	4606.500	0.529	0.05	Not Significant
	Female	113	97.77				
Student Working Status	Working	65	106.95	3903.000	0.234		Not Significant
	Not Workiing	134	96.63				
Parents' Education	Lower	102	91.95	4125.500	0.043		Significant
	Higher	97	108.47				
Section	Regular	111	94.15	4235.000	0.107		Not Significant
	Honors	88	107.38				

The analysis in Table 31 reveals a significant relationship between parents' education and student engagement in Problem-Based Learning (PBL) Mathematics, with a p-value of 0.043. This indicates that students with more educated parents tend to be more engaged in PBL Mathematics. Several factors contribute to this relationship: highly educated parents are more likely to be involved in their children's education, creating a supportive environment that encourages active engagement with PBL activities (Hernández-Padilla et al., 2023). Additionally, families with higher socioeconomic status have access to more educational resources, such as materials, technology, and extracurricular activities, which enhance students' ability to engage effectively with PBL tasks (Hernández-Padilla et al., 2023). Furthermore, educated parents possess cultural capital, including valued knowledge and norms, which helps students navigate educational systems and engage more deeply with learning (Bourdieu, 1986). These factors collectively support the notion that higher parental education levels positively influence student engagement in PBL Mathematics.

Table 32

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Difference in the Extent of Student Engagement in PBL Approach in Mathematics in the PBL Essential of Sustained Inquiry when Grouped by Demographics

Variable	Category	N	Mean Rank	Mann Whitney U	p-value	*Sig. level*	Interpretation
Sex	Male	86	98.84	4759.500	0.804		Not Significant
	Female	113	100.88				
Student Working Status	Working	65	104.47	4064.500	0.445		Not Significant
	Not Working	134	97.83			0.05	
Parents' Education	Lower	102	89.05	3830.500	0.006		Significant
	Higher	97	11.51				
Section	Regular	111	89.20	3685.000	0.003		Significant
	Honors	88	113.63				

Table 32 analyzes student engagement in the PBL approach to Mathematics, focusing on sustained inquiry across four demographic groupings. The p-values for sex (0.804) and student working status (0.445) are above 0.05, indicating no significant impact on engagement. However, the p-values for parents' education (0.006) and section (0.003) are below 0.05, signifying a significant influence on student engagement.

The same table further explores the statistical significance of these variables in relation to student engagement. It confirms that parents' education and section have a notable effect, while sex and student working status do not. This suggests that factors like parental education and section play a critical role in shaping engagement in the PBL approach to Mathematics. Davis-Kean et al. (2021) support these findings, highlighting socioeconomic status (SES) as a key predictor of academic performance and engagement. Their study shows that parental educational attainment, a key aspect of SES, significantly influences children's academic outcomes and the educational disparities that persist across generations.

Table 33
Difference in the Extent of Student Engagement in PBL Approach in Mathematics in the PBL Essential of Authenticity when Grouped by Demographics

Demographics	Category	N	Mean Rank	Mann Whitney U	p-value	*Sig. level*	Interpretation
Sex	Male	86	101.41	4737.500	0.762		Not Significant
	Female	113	99.68				
Student Working Status	Working	65	100.38	4330.500	0.949		Not Significant
	Not Working	134	99.82			0.05	
Parents' Education	Lower	102	86.44	3564.000	0.001		Significant
	Higher	97	114.26				
Section	Regular	111	83.56	3059.500	0.000		Significant
	Honors	88	120.73				

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Table 33 analyzes student engagement in Mathematics through the PBL approach, focusing on authenticity. The p-values for sex (0.762) and student working status (0.949) are above 0.05, showing no significant impact on engagement. However, parents' education (0.001) and section (0.000) are below 0.05, indicating these factors significantly influence student engagement. These findings highlight the importance of parental education and academic section in shaping engagement while sex and working status have no significant effect. Almulla (2020) supports this, showing that PBL enhances student engagement by fostering collaboration, understanding, and authentic learning. His study also found a link between higher parental education and improved student engagement, underlining the role of parental education in academic success and well-being.

Table 34

Difference in the Extent of Student Engagement in PBL Approach in Mathematics in the PBL Essential of Collaboration when Grouped according to Demographics

Demographics	Category	N	Mean Rank	Mann Whitney U	p-value	*Sig. level*	Interpretation
Sex at Birth	Male	86	100.42	4823.000	0.929	0.05	Not Significant
	Female	113	99.68				
Student Working Status	Working	65	103.60	4121.000	0.538		Not Significant
	Not Working	134	98.25				
Parents' Education	Lower	102	86.88	3609.000	0.001		Significant
	Higher	97	113.79				
Section	Regular	111	84.48	3161.000	0.000		Significant
	Honors	88	119.58				

The results in Table 34 illustrate that student section (p = 0.000) and parental education (p = 0.001) have significant impacts on participation in Problem-Based Learning (PBL) Mathematics, whereas gender and working status are not significant (p > 0.05). This is in agreement with research showing that higher levels of parental education are associated with increased access to educational resources and engagement (e.g., establishing supportive learning climates and providing means such as math problem-solving software), which enhances students' ability to interact with PBL activities. Collaborative dynamics of PBL, as emphasized by Makkonen et al. (2021), also increase participation by fostering peer-to-peer interaction and collective problem-solving, which enhance both cognitive knowledge and socioemotional capabilities. Their research on talented physics students revealed that the PBL focus on autonomy and collaboration provoked interest and engagement, although learning outcomes were similar to those of traditional approaches. Likewise, studies on PBL in mathematics highlight its capacity to ground abstract principles in real-world contexts, engaging curiosity and enthusiasm for the subject through collaborative learning structures. These aggregate results indicate that PBL's collaborative framework, paired with supportive academic and familial contexts, motivates genuine engagement in math education.

Table 35

Difference in the Extent of Student Engagement in PBL Approach in Mathematics in the PBL Essential of 21st Century Skills when Grouped according to Demographics

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Demographics	Category	N	Mean Rank	Mann Whitney U	p-value	*Sig. level*	Interpretation
Sex at Birth	Male	86	94.52	4387.500	0.240		Not Significant
	Female	113	104.17				
Student Working Status	Working	65	100.25	4338.500	0.965		Not Significant
	Not Working	134	99.88			0.05	
Parents' Education	Lower	102	86.25	3544.500	0.001		Significant
	Higher	97	114.46				
Section	Regular	111	84.60	3174.500	0.000		Significant
	Honors	88	119.43				

Table 35 compares student engagement in Mathematics through the PBL framework, specifically focusing on 21st Century Skills. The analysis shows that variables such as gender (0.240) and student working status (0.965) have no statistical significance, while parents' education (0.001) and student section (0.000) are significant. These findings highlight the influence of parental education and student section on engagement and the development of 21st Century Skills within PBL.

This underscores the importance of considering these factors when implementing PBL to enhance student involvement and outcomes in Mathematics education. Tailoring interventions to account for demographic and contextual differences is crucial, particularly for fostering 21st Century Skills. Rehman et al. (2023) studied PBL's impact on primary students' 21st Century skills, focusing on collaboration, critical thinking, and engagement. Their findings showed that PBL significantly improved these skills, supporting its efficacy in preparing students for modern challenges. The study emphasizes the importance of PBL in developing essential skills like problem-solving and communication for the 21st century.

Table 36

Difference in the Extent of Student Engagement in PBL Approach in Mathematics in the PBL Essential of Public Product when Grouped according to Demographics

Demographics	Category	N	Mean Rank	Mann Whitney U	p-value	*Sig. level*	Interpretation
Sex	Male	86	97.94	4682.000	0.659		Not Significant
	Female	113	101.57				
Student Working Status	Working	65	102.02	4224.000	0.730		Not Significant
	Not Workiing	134	99.02			0.05	
Parents' Education	Lower	102	88.96	3821.000	0.005		Significant
	Higher	97	111.61				
Section	Regular	111	86.80	3419.000	0.000		Significant
	Honors	88	116.65				

Table 36's analysis of student engagement within the PBL framework highlights the statistically significant influence of parents' education ($p = 0.005$) and student section ($p = 0.000$) on engagement related to public product creation, while gender and working status show no significant effects ($p > 0.05$).

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The significant role of parental education aligns with findings that higher-educated parents often provide greater access to resources like technology and math-related tools, fostering environments where students engage more deeply with complex, real-world tasks inherent to PBL. This is reinforced by studies showing that parental involvement and socioeconomic resources enhance students' capacity to connect abstract mathematical concepts to tangible applications, a cornerstone of PBL's effectiveness. Similarly, the significance of student section underscores the impact of classroom dynamics: sections prioritizing collaborative, student-centered learning—where peers co-create solutions and teachers facilitate autonomy—demonstrate higher engagement. Research indicates that such environments promote cognitive and emotional investment by allowing students to anchor learning in personal experiences and collective problem-solving, as seen in PBL's emphasis on teamwork and authentic problem statements. These factors collectively suggest that PBL's success in fostering engagement through public products depends on both external familial support and internal instructional structures that prioritize collaboration and real-world relevance

Conclusion

Although the generalization that women are more committed to their studies than men is not totally true, the statistics indicate that student participation in the Problem-Based Learning (PBL) method to mathematics is strong across a range of demographic groups. Notably, the PBL approach shows great promise as a teaching tool, encouraging in-depth learning and offering a stimulating atmosphere that promotes student achievement. Excellent student participation across a variety of categories and demographic characteristics makes this clear. However, it turns out that parental education level has a significant impact on kid participation, especially when it comes to driving questions. This emphasizes how crucial it is to take family dynamics into account while planning and carrying out PBL projects. Furthermore, parental education and section dynamics are important factors in determining student engagement, even while student participation in PBL components is consistent across some demographics like sex and employment level. In order to get the best results, it is imperative that these criteria be taken into consideration while creating and executing PBL programs in educational settings.

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Authorship Contribution Statement

Silfavan: Concept and design, literature review, data collection, analysis, and interpretation.
Asistido: Editing, reviewing, supervision, material support.

Conflict of Interest

The authors declare the absence of any conflict of interest that could have influenced the content or conclusions of this paper. They affirm that no financial, personal, or professional relationships with

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other individuals or organizations have compromised the objectivity, integrity, or impartiality of the research work. As a final point, no external parties influenced the study design, data collection, analysis, or interpretation.

References

Almarode, J. (2019). Teaching mathematics in the visible learning classroom, high school. Corwin Mathematics

Almulla, M. A. (2020, July). *The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning.* SAGE Open, 10(3), 215824402093870.https://doi.org/10.1177/2158244020938702

Amerstorfer, C. M., & Freiin von Münster-Kistner, C. (2021). Student perceptions of academic engagement and student-teacher relationships in problem-based learning. *Frontiers in psychology*, *12*, 713057.Barkley, E. F., & Major, C. H. (2020, May 5). *Student engagement techniques:* A handbook for college faculty (2nd ed.). San Francisco: Jossey-Bass.

Carrió, M., Rodríguez, G., & Baños, J. E. (2020, February 28). Effect of PBL implementation on student and teacher perceptions of improvement in 21st century skills. Research Square (Research Square). https://doi.org/10.21203/rs.2.24744/v1

C.-H. Chen, Y.-C. Yang. (2019, January 20). *Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators*. - ScienceDirect. https://doi.org/10.1016/j.edurev.2018.11.001

Cruz, S., Viseu, F., & Lencastre, J. A. (2022, July 8). *Project-Based Learning Methodology as a Promoter of Learning Math Concepts: A Scoping Review. Frontiers in Education.* https://doi.org/10.3389/feduc.2022.953390

Čubela, D., Rössner, A., & Neis, P. (2023, December 9). *Using Problem-Based Learning and Gamification as a Catalyst for Student Engagement in Data-Driven Engineering Education: A Report*. Education Sciences. https://doi.org/10.3390/educsci13121223

Dai, C.P., Ke, F.,& Pan, Y. (2022). *Narrative-supported math problem solving in digital game-based learning.Educational Technology Research and Development,70(4),* 1261-1281.https://doi.org/10.1007/s11423-022-10129-5

Davis-Kean, P. E., Tighe, L. A., & Waters, N. E. (2021, April). The Role of Parent Education in Parenting and Children's Development. Current Directions in Psychological Science, 30(2), 186–192. https://doi.org/10.1177/0963721421993116

De Vivo, K. (2022). *A NEW RESEARCH BASE FOR RIGOROUS PROJECT-BASED LEARNING*. The Phi Delta Kappan, https://www.jstor.org/stable/27116707

Handayani, AS, & Dian, D. (2021). *Application of Project Based Learning Learning Model Assisted by Video Learning to Increase Creativity in Artwork in Class II Students of SDN 2 Sungapan.* 1293–1303.

Hernández-Padilla, E., Bazán-Ramírez, A., Bazán-Ramírez, W., & Solano-Gutierrez, J. (2023, July 5). Parental participation and parents' support: effects on mathematics achievement, 2018 national assessment of learning, Mexico. Frontiers in Psychology, 14. https://doi.org/10.3389/fpsyg.2023.1154470

Humairah, H. (2021). *An analysis of mathematical reasoning ability in problem solving word problem based on gender at Universitas Muhammadiyah Lamongan.Jurnal Tunas Pendidikan*,3(2), 12-20.https://doi.org/10.52060/pgsd.v3i2.444

Hussein, B. (2021, August 16). *Addressing Collaboration Challenges in Project-Based Learning: The Student's Perspective. Education Sciences.* https://doi.org/10.3390/educsci11080434

Junisbayeva, S. (2020, June). *Project-based learning as an approach to develop critical thinking skills: A literature review. In Proceedings of International Young Scholars Workshop (*Vol. 9).

DOI: https://doi.org/10.56738/issn29603986.geo2024.5.90
ISSN 2960-3986
GEO Academic Journal Vol. 5 No. 1 – 2024 series

Krall, R. M., Wilhelm, J. A., & LeVaughn, J. M. (2022, December 22). *Project-Based Unit Development by Middle School Science Teachers: Investigations on Watershed Water Quality*. MDPI. https://doi.org/10.3390/educsci13010011

Larmer, J. (2020, July 22). *Gold Standard PBL: Essential Project Design Elements*. PBLWorks. https://www.pblworks.org/blog/gold-standard-pbl-essential-project-design-elements

Larmer, J. (2015). Setting the standard for project based learning. *A Proven Approach to Rigorous Classroom Instruction/ASCD*.Lugiati, L. (2020). *Using Project-Based Learning Model Using Audio Video to Improve Student Learning Outcomes. Journal of Education Action Research*, 4(4), 481. https://doi.org/10.23887/jear.v4i4.28645

Makkonen, T., Tirri, K., & Lavonen, J. (2021, June 2). Engagement in Learning Physics Through Project-Based Learning: A Case Study of Gifted Finnish Upper-Secondary-Level Students. Journal of Advanced Academics, 32(4), 501–532. https://doi.org/10.1177/1932202x211018644

MckKibben, J. D., & Murphy, T. H. (2021, March 28). *The Effect of Authenticity on Project-Based Learning: A Quasi-Experimental Study of STEM Integration in Agriculture. Journal of Agricultural Education*. https://doi.org/10.5032/jae.2021.01144

Mercer, S., and Dörnyei, Z. (2020). *Engaging language learners in contemporary classrooms. Cambridge: Cambridge University Press.* doi: 10.1017/9781009024563

Moliner, L., & Alegre, F. (2020). Effects of peer tutoring on middle school students' mathematics self-concepts. *Plos one*, *15*(4), e0231410.Nicholas, C., & Scribner, J. A. (2021, December 26). Enhancing PBL authenticity by engaging STEM professional volunteers. Interdisciplinary Journal of Problem-based Learning. https://doi.org/10.14434/ijpbl.v15i2.28734

Paryanto P, Munadi S, Purnomo W, Nugraha RN, Altandi SA, Pamungkas A, Cahyani PA (2023) *Implementation of a project-based learning model to improve employability skills and student achievement. In: AIP conference proceedings*, vol. 2671, No. 1. AIP Publishing. Yogyakarta, Indonesia

Permata, I. M., Nanda, B. J., & Cory, S. (2022, January 1). *Project-Based Learning: Enriching Students' 21st Century Skills*. Advances in Social Science, Education, and Humanities Research. https://doi.org/10.2991/assehr.k.220303.058

Postlethwait, D. E. (2023, August 24). *Project-Based Learning and its Impact on High School Students' Attitudes Towards Mathematics: A Quantitative Study. Scholars Crossing.* https://digitalcommons.liberty.edu/doctoral/4713

Radware Bot Manager Captcha. (2020). *https://iopscience.iop.org/article/10.1088/1742-6596/1456/1/012045/meta*

Rehman, N., Zhang, W., Mahmood, A., Fareed, M. Z., & Batool, S. (2023, July 18). *Fostering twenty-first century skills among primary school students through math project-based learning. Humanities and Social Sciences Communications.* https://doi.org/10.1057/s41599-023-01914-5

Riswari, L. A., & Bintoro, H. S. (2020, September 18). *THE INFLUENCE OF PROBLEM-BASED LEARNING MODEL IN IMPROVING STUDENT ENGAGEMENT IN MATHEMATICS.* Riswari | JPSD (Jurnal Pendidikan Sekolah Dasar). https://doi.org/10.30870/jpsd.v6i2.8679

Siedlecki, S. L. (2020, January). *Understanding Descriptive Research Designs and Methods. Clinical Nurse Specialist*, 34(1), 8–12. https://doi.org/10.1097/nur.0000000000000493

Sintema, E. J., & Jita, T. (2022, November 9). *Gender Differences in High School Students' Beliefs about Mathematical Problem Solving. Sintema | International Journal of Learning, Teaching and Educational Research.* https://doi.org/10.26803/ijlter.21.10.22

Teasley, S. D., & Roschelle, J. (2013). Constructing a joint problem space: The computer as a tool for sharing knowledge. In *Computers as cognitive tools* (pp. 229-258). Routledge.

DOI: https://doi.org/10.56738/issn29603986.geo2024.5.90
ISSN 2960-3986
GEO Academic Journal Vol. 5 No. 1 – 2024 series

Umar, M., & Ko, I. (2022, February 2). *E-Learning: Direct Effect of Student Learning Effectiveness and Engagement through Project-Based Learning, Team Cohesion, and Flipped Learning during the COVID-19 Pandemic. Sustainability.* https://doi.org/10.3390/su14031724

Yang, D., Skelcher, S., & Gao, F. (2021). *An investigation of teacher experiences in learning the project-based learning approach.* J Educ Learn (EduLearn) 15(4):490–504

Yin, Q., Guo, C., Dong, C., & Wang, T. (2021, March 18). *May problem-based learning get a higher evaluation from students?* | International Journal of Crowd Science. May Problem-based Learning Get Higher Evaluation From Students? | Emerald Insight. https://www.emerald.com/insight/content/doi/10.1108/IJCS-12-2020-0019/full/html

Yulhendri., Alisha, W. P., Sofya, R., Sudjatmoko, A., & Ritonga, M. (2022, July 21). *Analysis of Student Learning Engagement in Project-Based Learning | Atlantis Press*. Analysis of Student Learning Engagement in Project-Based Learning | Atlantis Press. https://doi.org/10.2991/aebmr.k.220702.093

Žerovnik, A., & Šerbec, I. N. (2021, January 1). *Project-Based Learning in Higher Education. Lecture Notes in Educational Technology.* https://doi.org/10.1007/978-981-16-2082-9_3

Zhao, Y., & Watterston, J. (2021, February 18). *The changes we need: Education post-COVID-19. Journal of Educational Change, 22, 3–12.* https://doi.org/10.1007/s10833-021-09417-3