

Enhancing 21st Century Skills through Project-Based Learning: Advancement of Mathematics Education for Preparatory Program Students

Nazirah Mat Russ¹, Maisarah Abdul Rahman¹ & Nur Nabila Ahmad Azam¹

¹Architecture and Environmental Design Department, Center for Foundation Studies,
International Islamic University Malaysia

Corresponding authors: nazirah@iium.edu.my

Received: 23 July 2023 | Accepted: 30 August 2023 | Published: 22 September 2023

Abstract: Ongoing discussions about the ability of graduates to thrive in modern organizations have spurred an urgent need for project-based learning (PBL) to enhance students' competence in soft skills (i.e., 21st century skills), which are essential in the workforce. PBL is widely touted as an effective interactive learning method, offering numerous advantages. However, the empirical evidence supporting its value in various subjects, courses, and learning contexts, especially in mathematics education, remains limited. Additionally, there is scant data on PBL implementation in the context of learning mathematics in the built environment. Therefore, this study aims to investigate students' perceptions of PBL implementation in mathematics education within the built environment. To gather quantitative data, a survey research strategy is proposed, using a questionnaire with a 5-point Likert scale and was administered to Architecture and Environmental Design (AED) program students from 2017/2018 to 2022/2023. The data collected from 63 respondents were analyzed using PLS-SEM. The results of the study indicate that the implementation of PBL in mathematics for the built environment is significant, positively impacting students' learning activities and fostering essential 21st century skills such as communication skills, interpersonal skills, teamwork, and project management ($t > 1.96$, $p \leq 0.05$). These findings are expected to have pedagogical implications, leading to improvements in learning quality and serving as a solution to enhance students' competency. Additionally, this study sheds light on the importance of PBL in the context of learning mathematics within the built environment, providing valuable insights into its impact on students' learning experiences and skill development.

Keywords: Mathematics, Preparatory Program, Project-Based Learning, 21st Century Skills

Cite this article: Nazirah Mat Russ, Maisarah Abdul Rahman & Nur Nabila Ahmad Azam. (2023). Enhancing 21st Century Skills through Project-Based Learning: Advancement of Mathematics Education for Preparatory Program Students. *Global Journal of Educational Research and Management (GERMANE)*, 3 (3), p. 22-37.

INTRODUCTION

In recent times, the concern regarding unemployment among graduates has escalated (Tharim et al., 2022; Maegala et al., 2021), with a strong correlation to competency (Tharim et al., 2022; Pesakovic et al., 2014). The notion of competency was initially introduced by White (1959) as a concept of performance motivation within career development (Pesakovic et al., 2014). Within an educational context, competency signifies the ability to apply knowledge, skills, attributes, and exceptional performance to tasks, along with the capacity for reflective learning (Pesakovic, 2014). In the realm of mathematics education, competency pertains to the skill of translating mathematical knowledge and skills into practical solutions (Vorobjovs, 2020).

Previous research has extensively highlighted various factors contributing to the shortage of competency among graduates, spanning beyond mathematics education. These factors encompass deficiencies in communication skills (Tharim et al., 2022; Hite & McDonald, 2020; Rahman et al., 2020), interpersonal skills (Rahman et al., 2020; Fraser et al., 2019), updated knowledge (Tharim et al., 2022), translating knowledge into practice (Tharim et al., 2022; Vorobjovs, 2020; Bahrim et al., 2019), and poor working performance (Bahrim et al., 2019). Thus, project-based learning (PBL) becomes one of the solutions. This approach is well-known for its many advantages, which can address the drawbacks of traditional teaching methods (i.e., teacher-centered learning), particularly in the field of mathematics education (Almulla, 2021; Alyani & Ratmanida, 2021; Elsamanoudy et al., 2021; Rostika et al., 2021; Susanti et al., 2019).

Although it has been successfully recorded (Widodo, et al. 2019; Barwell, 2013), the application of mathematics in resolving environmental issues (e.g., pollution, deforestation, natural disasters, and wastage) has received little attention (Mumu et al., 2021, Rosenshine, 2012). According to Rosenshine (2012), one of the causes is the shortage of mathematics textbooks that incorporate environmental issues. Additionally, compared to other fields like biology, engineering, chemistry, and information technology, there is little research of PBL implementation, particularly on the interaction between mathematics and the built environment. This study separates ten thousand and seventy-five studies (10075) connected to PBL implementation in mathematics education based on a comprehensive review of the literature. Only one hundred and thirty-two (132) studies were carried out in the context of the built environment. Furthermore, no evidence has been shown to show that the implementation of PBL in mathematics education may enhance the soft skills required. Thus, it is important to view this from the students' perspective because they are actively engaged in learning activities where PBL is implemented, and mathematics is particularly prevalent in the built environment field.

Since competency is commonly associated with PBL, this study seeks to examine the importance of PBL to learning mathematics based on students' perception within the context of the built environment, as aligned with Sustainable Development Goal 8 (SDG 8). SDG 8 aims for sustainable economic growth, full employment, and decent work. It includes measuring the progress of achieving this goal, especially in terms of youth employment (UNDP, 2022). To achieve this, three (3) objectives are established, (i) to determine students' perceptions of PBL implementation in mathematics for built environment toward overall learning, (ii) to determine students' perception of PBL implementation in mathematics for built environment toward soft skills acquisition, and (iii) to analyze the relationship between overall learning and soft skill acquisition, with the hope, to have positive impacts towards pedagogy that will improve the quality of learning and provide a way to increase students' competency.

LITERATURE REVIEW

This section discusses the existing literature in project-based learning (PBL) implementation among preparatory program students. It starts by defining the importance of preparatory programs in bridging the gap between high school outcomes and the needs of university study plans, followed by defining PBL and its assistance in building students' competency and soft skills needed in the workforce.

Preparatory program

To cater for the high unemployment rate, universities worldwide aim to prepare students for their academic and professional journeys while aligning with the demands of the job market

(Brdesee & Alsaggaf, 2021). As a result, a preparatory year is offered to address the disparity between high school achievements and university curriculum demands (Brdesee & Alsaggaf, 2021).

Existing literature (Tharim et al., 2022; Abelha et al., 2020; Buheji & Buheji, 2020; Rahman et al., 2020; Farhadi et al., 2020; Moshood et al., 2020; Kadir et al., 2020; Bahrim et al., 2019; Romgens et al., 2019) suggests that addressing the issue of graduate competency entails enhancing education quality by shifting the emphasis from teacher-centered to student-centered learning. This is because the preparatory year marks students' initial support phase in the life of university students and has held significance for many years (Lugt, 2020). It is widely acknowledged as a pivotal period in students' university experience, which they cultivate and enhance their skills, and make decisions about their academic specialization, which will shape their educational and career life (Brdesee & Alsaggaf, 2021; Lugt, 2020).

Furthermore, teaching and learning as well as assessment should be modified, with a pronounced focus on skill development and bridging the gap between knowledge and practical application (Tharim et al., 2022; Kadir et al., 2020; Romgens et al., 2019). According to Maegala et al. (2021), the acquisition of competency is closely linked to several learning strategies such as project-based learning, problem-based learning, and research-based learning.

Project-based learning (PBL)

Project-based learning (PBL), problem-based learning, and research-based learning are three learning strategies that are strongly related to competency (Maegala et al., 2021). Additionally, prior research (Guo et al., 2020; Bakar et al., 2019) asserted that PBL and problem-based learning are sometimes used synonymously in situations where they are overly connected. This is because both teaching methods center on solving a problem. But PBL places a strong emphasis on knowledge construction, which encourages innovation competency (Guo et al., 2020). While problem-based learning, which is discovered to be a component of PBL, only emphasizes knowledge applications (Guo et al., 2020). The focus of research-based learning, on the other hand, is on developing research questions, contextualizing them in light of the literature, choosing a theoretical framework and research methodology, conducting methodological investigations or observations of phenomena, evaluating and interpreting research data, and formulating and presenting the findings (Vlajkovic, 2023).

Upon the above comparison, this study found that PBL has become one of the solutions in learning mathematics especially for built environment preparatory program students. There has been much discussion and disagreement over how PBL should be implemented in mathematics education. In the context of a built environment which refers to human-made surroundings (i.e., building, park, and infrastructure), mathematics knowledge is necessary (Mumu et al., 2021). This is due to the numerous calculations that go into generating a human-made surrounding (Mumu et al., 2021; Verner & Maor, 2003). According to Mumu et al. (2021), students need to have a solid grasp of mathematical concepts and informed awareness of environmental issues to address any environmental mathematics-related problems.

There is no specific definition of PBL but several researchers (Amin et al, 2022; Almulla, 2021; Alyani & Ratmanida, 2021; Elsamanoudy et al., 2021; Rostika et al., 2021; Susanti et al., 2019) refer to PBL as the student-centered learning which allows the students to learn by actively engaging in real-world challenges and problems. PBL is a specific instructional approach that involves students working on projects to gain deeper knowledge and

understanding of a topic (Kamal et al., 2022). It focuses on solving real-world problems which encourage the students to explore, analyze, and present their solutions. Although PBL encourages autonomy and exploration, it is typically structured around specific projects or tasks that the instructor provides (Kamal et al., 2022). Besides, it is often done in collaborative teams, which enhances 21st century skills: communication, teamwork, and interpersonal skills, as well as project management in addition to practical application of the knowledge (Kamal et al., 2022).

21st century skills

In a current real workplace setting, 21st century skills for instance communication skills, interpersonal skills, teamwork, as well as project management and being innovative are essential aspects of job competence (Musa et al., 2012). Thus, the discussion is further extended by exploring the mentioned skills involved, which can be acquired through PBL implementation.

a) *Communication skills:*

Communication skills encompass both verbal (spoken) and non-verbal (written) forms. Verbal communication is demonstrated through presentations and discussions, while non-verbal communication is evident in project reports (Syahril et al., 2021). In the context of mathematics education, communication skills involve conveying mathematical concepts through verbal means (e.g., discussing, presenting, explaining) and non-verbal methods (e.g., using images, graphs, tables, equations) (Lestari & Yudhanegara, 2015). Furthermore, this skill set includes the ability to comprehend and embrace the critical analytical and mathematical ideas of others, along with the capacity to evaluate them (Lestari & Yudhanegara, 2015).

b) *Interpersonal skills:*

Interpersonal skills refer to openness, empathy, positive attitude, unity, interaction management, expression, and orientation to other group members (Sunigsih et al., 2017). Interpersonal skills are essential when applying mathematical knowledge to real-world scenarios. This is because students need to explain mathematical concepts to their peers, which not only reinforces their own understanding but also enhances their ability to convey complex ideas clearly to others and behave accordingly during group discussion (Elsamanoudy et al., 2021; Syahril et al., 2021).

c) *Teamwork:*

Teamwork refers to social skills such as attentive listening and effective speaking. Within an educational framework, students address challenges by mastering the art of attentive listening, inquiring thoughtfully, providing input, and confidently expressing their thoughts during collaborative exchanges (Syahril et al., 2021). Many real-world scenarios involve teamwork to solve mathematical problems. Collaborative mathematics learning helps students prepare for situations where they may need to collaborate with colleagues in various fields (Syahril et al., 2021).

d) *Project management:*

Project management activity refers to the project's operational procedure of including setting schedule, writing project proposal, as well as sharing ideas (Syahril et al., 2021). In this study's context, project management activity denotes any procedure to complete the project report including sharing ideas, gathering the mathematical information for the project, as well as recognizing the relevant ideas obtained from reading materials.

RESEARCH METHODOLOGY

This study employed a survey research strategy to derive the quantitative data through a questionnaire with a numerical rated item of a 5-point Likert scale. The respondents need to measure their perception on five constructs which consist of twenty-seven (27) items in which 1 denotes strongly disagree and 5 denotes strongly agree. Furthermore, the data collected from the students of the Architecture and Environmental Design (AED) program within the academic year of 2017/2018 to 2022/2023 were then analyzed using PLS-SEM.

Population and sampling

The population of the study consists of all graduates from the Architecture and Environmental Design (AED) program at the Centre for Foundation Studies of International Islamic University Malaysia (CFSIUM) between the academic years 2017/2018 to 2022/2023. To note, the chosen academic year for data collection only spans from 2017/2018 to 2022/2023, as the PBL method was just introduced in Introduction to Mathematics for the Built Environment at the beginning of the 2017/2018 academic year. About 1400 students graduated from the AED program during the aforementioned academic year, according to data from the CFSIUM administrative office.

However, due to time and accessibility limitations, a representative subset is necessary. Additionally, given the absence of a sampling frame, the chosen sampling technique is voluntary sampling. The survey questionnaire was administered online via the alumni WhatsApp group and Facebook, spanning from March 10th to April 9th, 2023. As recommended by Krejcie & Morgan (1970), an appropriate sample size is determined to be 302. Notably, previous researchers (Takim & Adnan, 2008; Adnan & Morledge, 2003; Ofori & Lean, 2001; Vidogah & Ndekugri, 1998) have indicated an acceptable response rate of 20% to 30% for questionnaire surveys. In the present study, a total of 63 valid responses were collected, constituting 20.9% of the intended sample size.

Survey instruments

The survey instruments utilized in this study were adapted from established questionnaires to suit the study environment. These adaptations were made based on the established validity and reliability of the questionnaires. The questionnaire employed in this research contained twenty-seven items, organized into five categories: overall learning (OL) with 8 items (Elsamanoudy et al., 2021; Syahril et al., 2021), communication skills (CS) with 4 items (Elsamanoudy et al., 2021; Syahril et al., 2021; Zulkarnain et al., 2021), interpersonal skills (IS) with 5 items (Elsamanoudy et al., 2021; Syahril et al., 2021), teamwork activity (TA) with 6 items (Elsamanoudy et al., 2021; Syahril et al., 2021), and project management activity (PM) with 4 items (Elsamanoudy et al., 2021; Syahril et al., 2021).

Reliability test

This study adhered to the suggestion of several scholars (Hair et al., 2019; Goforth, 2015; Zainuddin, 2012) by adopting a minimum Cronbach's alpha value of 0.6, while also considering the upper threshold of 0.9 as recommended by Tavakol and Dennick (2011). The findings of this study affirm that Cronbach's alpha values falling within the range of 0.6 to 0.9 indicate a strong level of reliability, in line with earlier discourse on the subject.

Table 1. Cronbach alpha

Latent variables (Constructs)	Cronbach's alpha value
Communication skills (CS)	0.713
Interpersonal skills (IS)	0.685
Teamwork activity (TA)	0.729
Project Management activity (PM)	0.701
Overall Learning (OL)	0.883

Hypotheses

Four hypotheses were developed based on the earlier study (Elsamanoudy et al., 2021; Syahril et al., 2021) to be tested as depicted in Figure 1.

H1: There is a positive association between overall learning and communication skills

H2: There is a positive association between overall learning and project management activity

H3: There is a positive association between overall learning and teamwork activity

H4: There is a positive association between overall learning and interpersonal skills

Although prior research has indicated positive correlations, this study chose to assess the hypotheses specifically within the context of implementing PBL in mathematics for the built environment, in contrast to the previous studies that focused on distinct fields like engineering and biology. To determine the statistical significance of the variables, the t-test is utilized as a hypothesis testing tool. In this study, a two-tailed test is employed. Consequently, if the calculated t-value exceeds 1.96 ($t > 1.96$) at a 95% confidence interval, with the corresponding p-value equal to or below 0.05 ($p \leq 0.05$) as per Malhotra (2003), then the alternative hypothesis is affirmed.

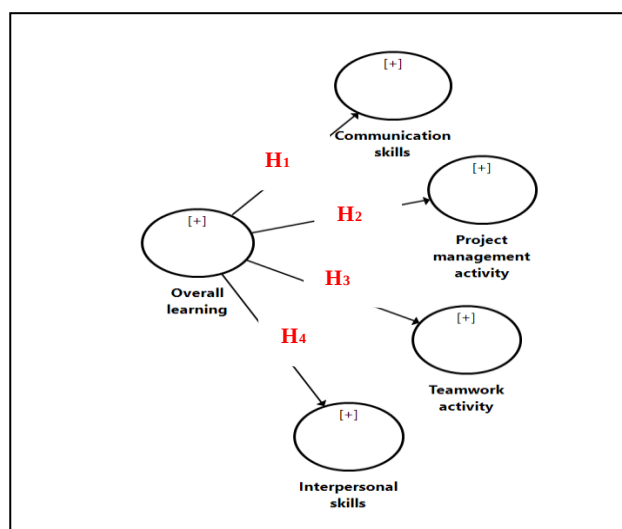


Figure 1. Proposed model

RESULTS

The section commenced with basic statistical analysis, employing descriptive analysis through SPSS and advanced statistical approach, Partial Least Square Structural Modeling (PLS-SEM), was employed to answer the objectives of this study.

Descriptive Analysis

In this study, univariate descriptive analysis was utilized, as illustrated in the subsequent tables. Based on the descriptive analysis, the majority of the respondents are female. Out of all respondents, forty-one were female (65.1%) and twenty-two were male (34.9%) as depicted in Table 2. Additionally, as indicated in Table 3, most respondents, twenty respondents, accounting for 31.8% of the total sample completed their studies at CFSIUM in 2023. Subsequently, there were eighteen respondents (28.6%) who graduated in 2022, followed by twelve respondents (19%) in 2019, five respondents (7.9%) in 2020, four respondents (6.3%) in 2017, three respondents (4.8%) in 2018, and one respondent (1.6%) in 2021.

i) **Gender:** The respondents' gender is provided in Table 2.

Table 2. Respondents' gender

Gender	Frequency	Percentage (%)
Female	41	65.1
Male	22	34.9
Total	63	100

ii) **Graduation Year:** The year respondents graduated from the CFSIUM is presented in Table 3

Table 3. Respondents' graduation year

Gender	Frequency	Percentage (%)
2017	4	6.3
2018	3	4.8
2019	12	19
2020	5	7.9
2021	1	1.6
2022	18	28.6
2023	20	31.8
Total	63	100

Advance statistical analysis

In the context of advanced statistical analysis, this study proceeded with confirmatory factor analysis (CFA), evaluation of the measurement model, and examination of the structural model. These tasks were carried out using partial least square structural modeling (PLS-SEM) through the SmartPLS software. Following the CFA on aspects like overall learning, communication skills, interpersonal skills, teamwork activity, and project management activity, a total of twenty-seven items/indicators with weights exceeding 0.10 were retained for subsequent analysis. The comprehensive model for this study was constructed using SmartPLS, employing the PLS algorithm with the path weighting scheme, as illustrated in Figure 2. The measurement model (outer model) illustrates the connections between manifest variables (i.e., items/indicators), represented by rectangular shapes, and their corresponding latent variables (i.e., constructs), depicted as ovals. Conversely, the structural model (inner model) portrays the interrelationships existing among the latent variables.

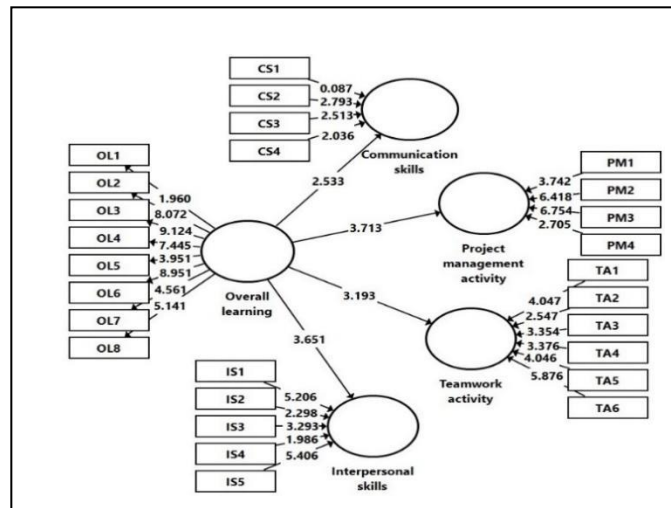


Figure 2. Inner and outer model (i.e., full model) - Bootstrapping t-values

Table 4. Summary of reflective assessment model

Reflective construct (Latent variable)	Reflective indicators (Manifest variables)	Outer loading	Dijkstra-Henseler's rho (pA)	AVE	HTMT
Overall learning (OL)	OL1	0.750	0.808	0.56 (56%)	0.749
	OL2	0.832			
	OL3	0.844			
	OL4	0.829			
	OL5	0.739			
	OL6	0.792			
	OL7	0.727			
	OL8	0.702			

Legend: AVE - average variance extracted, HTMT - heterotrait-monotrait

Table 5. Summary of formative assessment model

Formative construct (Latent variable)	Formative indicators (Manifest variables)	RA	VIF	Outer weight	Outer loading	t-value (> 1.96)	p-value (<0.05)	Sig.
Communication skills (CS)	CS1	0.795	1.792	0.038	0.638	0.087	0.931	No
	CS2		2.180	0.198		2.793	0.005	Yes
	CS3		2.760	0.659		2.513	0.012	Yes
	CS4		2.734	0.263		2.036	0.042	Yes
Interpersonal skills (IS)	IS1	0.811	2.355	0.317	0.806	5.206	0.000	Yes
	IS2		3.774	-0.149		2.298	0.022	Yes
	IS3		3.842	0.161		3.298	0.026	Yes
	IS4		2.617	0.485		1.986	0.047	Yes
	IS5		3.549	0.321		5.406	0.000	Yes

Table 6. Summary of formative assessment model (cont'd)

Formative construct (Latent variable)	Formative indicators (Manifest variables)	RA	VIF	Outer weight	Outer loading	t-value (>1.96)	p-value (<0.05)	Sig.
Project management (PM)	PM1	0.834	3.376	0.081	0.713	3.742	0.000	Yes
	PM2		4.245	0.625		6.418	0.000	Yes
	PM3		3.577	0.259		6.754	0.000	Yes
	PM4		2.390	0.126		2.705	0.002	Yes
Teamwork (TA)	TA1	0.716	4.242	0.190	0.817	4.047	0.000	Yes
	TA2		3.397	-0.002		2.547	0.011	Yes
	TA3		3.064	0.298		3.354	0.001	Yes
	TA4		3.418	0.132		3.376	0.001	Yes
	TA5		3.783	-0.027		4.046	0.000	Yes
	TA6		4.109	0.781		5.878	0.000	Yes

Legend: RA – redundancy analysis, VIF - variance inflation factor

Table 7. Correlation between PBL implementation on overall learning with soft skills acquisition

	t-value (> 1.96)	p-value (<0.05)	Significance	Hypothesis supported?
Overall learning → communication skills	2.533	0.012	Yes	Yes
Overall learning → interpersonal skills	3.651	0.000	Yes	Yes
Overall learning → project management activity	3.713	0.000	Yes	Yes
Overall learning → teamwork activity	3.193	0.001	Yes	Yes

DISCUSSION

This section provides a discussion of the study results to highlight the achievement of the study objectives.

1. To determine students' perceptions of PBL implementation in mathematics for built environment toward overall learning:

Based on Table 4.3, the latent variable of overall learning is reflected by eight manifest variables. The results suggest that respondents generally agree that PBL has positively influenced their overall learning experience in mathematics, from course comprehension to practical application, teamwork, self-regulation, communication, and motivation. The result indicates the highest improvement in terms of teamwork and collaboration skill, which was found to be the first in the ranking with the highest loading of 0.844. The results of this study align with the discoveries in existing literature. For instance, Syahril et al. (2021) emphasized that PBL has the potential to enhance students' abilities in teamwork and collaboration, as this approach encourages students to share responsibilities and collaborate as a cohesive unit to tackle assigned tasks. While the least improvement is in terms of increasing motivation to learn mathematics with the lowest loading of 0.702. This study aligns with the research outcome of Kadir et al. (2013) concerning a comparable recognized constraint, namely, the duration of PBL implementation. Kadir et al. (2013) pointed out that students' motivation to learn remained consistent, likely due to their limited familiarity with the new learning

approach, as they encountered PBL for just one semester. Similarly, in this study, students also engaged in PBL-based mathematics learning for a single semester, which may have influenced their motivational outcomes.

2. To determine students' perception of PBL implementation in mathematics for built environment toward soft skills acquisition:

The following paragraph will discuss students' perception of soft skills, often referred to as 21st century skills acquisition in detail.

i) *Communication skills:*

Based on Table 4.4, the latent variable of communication skills is formed by four manifest variables. The result suggests that respondents generally agree that PBL has positively enhanced their non-verbal communication skills, including organizing mathematical ideas in reports, interpreting mathematical data, employing appropriate mathematical language, and responding effectively to task-related messages. The result indicates an enhancement in respondents' writing skills. In the context of learning mathematics, respondents were proficient in employing accurate mathematical principles, terminology, and language within their project reports, reflected in the highest weight of 0.659. Upon reviewing the submitted project reports, this study observed an improved ability among respondents to effectively convey their mathematical reasoning to various readers, including lecturers and peers. However, respondents displayed relatively less progress in effectively presenting mathematical ideas through diagrams, notation, and symbols, as evidenced by the lowest weight of 0.038. This outcome corresponds with previous research, such as the study conducted by Rohid et al. (2019), which found that only a third of students excelled in expressing mathematical ideas using symbols and notation. Similar concerns were identified by Rustam and Ramlan (2017), who highlighted students' struggles in effectively communicating their mathematical concepts. Furthermore, informal observations during this study suggested that students' language difficulties were linked to challenges in transforming narrative questions into mathematical diagrams, notation, operations, and symbols.

ii) *Project management:*

Based on Table 4.4, the latent variable of project management is formed by four manifest variables. The results suggest that respondents generally agree that PBL has positively enhanced various aspects of project management, including effective idea sharing, information gathering, relevant information identification, and confident contribution within group settings. The result indicates that the most substantial improvement was observed in respondents' capacity to brainstorm and collaborate on ideas to successfully complete assigned tasks, yielding the highest weight of 0.625. Informal observations during the study revealed that the implementation of PBL fosters a sense of positive challenge among students, thereby encouraging active engagement and a strong commitment to generating high-quality project reports. Moreover, in line with this, Kadir et al. (2013) also emphasized that PBL cultivates students' self-assurance and autonomy, leading to a sense of empowerment and enjoyment when collaborating on project tasks with peers. In contrast, the respondents displayed comparatively less improvement in their ability to identify pertinent mathematical information from the provided reading materials, as evidenced by the lowest weight of 0.081. This might be attributed to challenges in comprehending and interpreting mathematical data and information, potentially resulting in difficulties in recognizing the relevant content from the materials provided.

iii) Interpersonal skill:

Based on Table 4.4, the latent variable of interpersonal skills is formed by five manifest variables. The result suggests that respondents generally agree that PBL has positively enhanced various aspects of interpersonal skills, including sensitivity to others' needs, successful collaboration, language usage, social skills, and appropriate interaction strategies. A significant enhancement in active participation among group members during the project contributed to the development of their interpersonal skills, encompassing appropriate language usage and behavior in both formal and informal contexts, as indicated by the highest weight of 0.485. This finding aligns with the outcomes observed in the research by Elsamanoudy et al. (2021) and Syahril et al. (2021). Conversely, the respondents exhibited the least progress in terms of becoming more perceptive and attuned to the needs of their peers within their group work, garnering a weight of 0.149. This result diverged from the conclusions of earlier studies conducted by Syahril et al. (2021) and Musa et al. (2012). Moreover, informal observations suggest that reduced perceptiveness and sensitivity are closely associated with passive students, who may struggle with active listening and introspection.

iv) Teamwork:

Based on Table 4.4, the latent variable of teamwork is formed by six manifest variables. The result suggests that respondents generally agree that PBL has positively enhanced various aspects of teamwork, including active listening, appropriate communication, assertiveness, understanding the significance of teamwork, effective group studying, and improved comprehension through group discussions. The statement "I learned that good teamwork contributes to a successful outcome of the project" exhibited the highest improvement among respondents, garnering a weight of 0.781. This outcome underscores the advantages of the PBL approach emphasized in existing literature (Almulla, 2021; Alyani & Ratmanida, 2021; Elsamanoudy et al., 2021), which asserts that PBL enhances collaborative efforts among group members, leading to effective teamwork and successful project outcomes. In contrast, the respondents demonstrated the least advancement in terms of being assertive when exchanging ideas within their group, with a weight of 0.002. This finding diverges from the outcomes of a previous study conducted by Syahril et al. (2021) on the same aspect, where the mean value was 4.24 (high). According to Syahril et al. (2021), high student motivation and active team-based learning contribute to increased assertiveness among students. Furthermore, this perspective aligns with the findings of this research, as presented in Table 4, where lower motivation to learn mathematics corresponds to a lower mean value associated with assertiveness.

3. To analyze the relationship between overall learning and soft skill acquisition:

The discussion was divided into two sections: measurement model assessment, and structural model assessment.

i) Measurement model assessment:

There are two measurement models: reflective and formative (Hair et al., 2019), each adhering to distinct criteria (Hair et al., 2019). In this study, both models were utilized, with reflective application for overall learning and formative application for communication skills, interpersonal skills, teamwork, and project management. As shown in Table 4.3, all reflective indicators exhibit outer loadings exceeding 0.70, indicating that the concept possesses satisfactory item reliability by accounting for over 50 percent of the variance in the indicators. Furthermore, the Dijkstra-Henseler's rho (pA) value of 0.808 signifies the presence of internal consistency reliability. The AVE value of 0.56 signifies that the construct

explains 56 percent of the variance in its items, while the HTMT value of 0.749 confirms both convergent validity and discriminant validity. Besides, as shown in Table 4.4, all formative indicators exhibited significance, as indicated by outer weights exceeding 0.10 (disregarding the negative sign of outer weights) (Chin, 1998). There were four exceptions: CS1, PM1, TA2, and TA5, with outer weights falling below 0.10. Nevertheless, this study opted to retain these indicators due to their outer loadings surpassing 0.50, as emphasized by Hair et al. (2017). While these indicators were deemed to be absolutely important, their relative importance was somewhat lower. Consequently, the outcomes of the measurement model assessment validated the effectiveness of both the formative and reflective models adopted in this study.

ii) **Structural model assessment:**

Moving on to the assessment of the structural model (the inner model), it elucidates the interconnections existing among the latent variables. Table 4.11 provides a concise overview of the estimates of path coefficients, accompanied by t-values and p-values. The outcome reveals that the coefficients of the inner paths were both statistically significant and relevant. This determination is guided by t-values surpassing 1.96 and p-values falling below 0.05, in accordance with Hair et al. (2017). In addition, the study deduced that all hypotheses, encompassing both first-order and second-order constructs, garnered support from these outcomes. This alignment with Malhotra (2003) indicates that hypotheses are upheld when the significance level is 5% or less ($p \leq 0.05$).

CONCLUSION

Exploring students' perspectives is a strategic approach to enhancing teaching methods, learning experiences, and curriculum development. The outcomes of this study reveal that a majority of the respondents hold a favorable view of utilizing Project-Based Learning (PBL) in mathematics education. This implies that PBL holds significant value as a pedagogical approach for learning mathematics in the context of the built environment. It has the potential to enhance students' learning engagement and facilitate the acquisition of crucial soft skills such as communication skills, interpersonal skills, teamwork, and project management. As a result, the study has successfully accomplished its first and second objectives. Furthermore, the study identifies a positive correlation between the implementation of PBL in mathematics education and the development of soft skills, thereby accomplishing its third research objective.

The findings of this study hold significance for both theoretical and practical contexts. Theoretically, the model developed in this study could serve as a foundational framework for researchers exploring similar concepts across diverse subjects, courses, and learning domains. Moreover, the study's outcomes have the potential to inform educational practices and foster awareness, leading to an enhancement in the quality of learning experiences and ultimately contributing to the development of students' competencies.

Considering the need for further investigation, this study recommends that its results should undergo verification in various pre-university settings to ensure their applicability and relevance across different educational contexts. Additionally, it is worth noting that the absence of model validation through interviews represents a limitation in this study. Therefore, it is suggested that future research endeavors incorporate interview validation to address this limitation and further enhance the study's comprehensiveness.

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