Problem-Based Learning Approach for Developing Learning Management Skills in Undergraduate Mathematics Education

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Abstract. This study explores the effectiveness of problem-based learning (PBL) activities in developing learning management skills among mathematics education students. The research was conducted with 30 participants selected from a public university in Thailand using a cluster sampling method. A holistic rubric with a rating scale of 1 to 5 was employed to assess learning management design and teaching implementation. The results indicate that PBL significantly enhanced students' learning management skills, with mean scores of 77.90 (82% of full mark) for learning management design and 56.90 (81.29% of full mark) for teaching implementation. Overall, the participants achieved a mean score of 134.80 (81.70% of full mark), demonstrating the effectiveness of PBL in fostering comprehensive learning management abilities. Moreover, participants expressed high satisfaction with the PBL approach, as evidenced by a mean satisfaction score of 4.54 (S.D. = 0.48) on a 5-point Likert scale. The study contributes valuable evidence supporting the integration of PBL in teacher education curricula, with implications for both academic and pedagogical contexts. Policymakers are encouraged to consider incorporating real-world problem-solving experiences in all teacher education classes, and further studies can explore the long-term effects of PBL on students' teaching practices.

Keywords: PBL; teacher education; learning management skills; pre-service teacher development; teaching skills

1. Introduction

Learning management skills play a crucial role in the education field, particularly for students pursuing a career as teachers (Dennison & Shenton, 1989; Oliver & Reschly, 2007). Just as class knowledge is essential for educators, learning management skills are equally important. These skills encompass the ability to

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effectively organise, plan, assess and adapt instructional strategies in the classroom. In other words, learning management skills are the foundation upon which educators can create a conducive learning environment and facilitate meaningful student engagement (Oliver & Reschly, 2014). Recognising the significance of these skills is vital, as they directly influence the success and impact of future teachers (Dennison & Shenton, 1989; Evertson & Weinstein, 2006).

However, it is important to acknowledge that developing learning management skills is not a straightforward task. The complexity arises from several factors that make it challenging for education students to acquire and refine these skills (Bas, 2019). To elaborate, learning management skills encompass a wide range of competencies, including classroom management, instructional design, student assessment and fostering a supportive learning environment. Mastering each of these areas requires time, practice and guidance. Thus, it comes as no surprise that many education students face difficulties in their journey to develop these essential skills (Isuku, 2018).

One possible explanation for the difficulty in developing learning management skills could be attributed to traditional teaching methods that rely heavily on lectures and memorisation. Such instructional approaches often prioritise the transmission of knowledge rather than focusing on the practical application of that knowledge. According to Alaagib et al. (2019), while lectures may effectively deliver content, they fall short in fostering the necessary skills and competencies required for effective learning management. This highlights the need for alternative methods that emphasise active engagement and problem-solving.

As mentioned, learning management skills are complex and cannot be developed solely through passive learning approaches. Real-world classroom contexts pose various challenges that need dynamic management skills. Factors such as learner differences, varying levels of teaching support, classroom dynamics and student readiness further complicate the task of managing a classroom effectively. To overcome these challenges, instructional methods that provide opportunities for learners to experience and navigate authentic problems can significantly contribute to the development of learning management skills (Yang & Harbor, 2023).

In the context of the challenges faced by education students in acquiring learning management skills, it is crucial to explore effective pedagogical strategies. Problem-based learning (PBL) emerges as a promising approach to address these challenges. PBL immerses students in real-world problems, encouraging active engagement, critical thinking, collaboration and decision-making skills—essential components of effective learning management (Barell, 2006; Boud & Feletti, 2013; Hung et al., 2019). By presenting authentic challenges, PBL aligns with the complexities of real classroom contexts and offers students the opportunity to develop their learning management skills while actively solving complex problems. In the current study, we employed PBL as a pedagogical strategy aimed at enhancing the learning management skills of mathematics education students, bridging the gap between theory and practice in the education field.

2. Literature Review

2.1 Learning Management Skills

Learning management skills encompass various aspects that are crucial for effective instructional planning and management (Dennison & Shenton, 1989; Oliver & Reschly, 2007). In the context of learning management plan design, several key components need to be considered. First, the understanding of learning components is essential, which involves recognising the diverse elements that contribute to effective learning, such as learner characteristics, learning environments and instructional strategies (Kats, 2013). Additionally, determining appropriate learning contents that align with curriculum goals and student needs is crucial (Gagne et al., 2004). This includes selecting and sequencing relevant topics, concepts and skills to be taught. Furthermore, setting clear and measurable learning objectives that guide instruction is vital. These objectives articulate what students should know, understand and be able to do by the end of a lesson or unit.

Another aspect of learning management plan design is the selection of principles in the learning management process (Smith, 2004). Educators need to consider research-based principles of effective instruction, such as differentiation, scaffolding and active engagement, to enhance student learning. Additionally, the choice and development of appropriate learning materials, including textbooks, supplementary resources and technology-based tools, play a significant role in facilitating learning. Finally, evaluation and assessment strategies should be incorporated to gauge student progress and inform instructional decisions (Brookhart & Nitko, 2018). This involves selecting appropriate assessment methods, designing valid and reliable assessments, and using assessment data to adjust instruction and provide meaningful feedback to students.

Teaching skills are another critical aspect of learning management. Within this domain, several key skills contribute to effective classroom instruction. First, the skill of lesson introduction is crucial in capturing students' attention, activating their prior knowledge, and setting clear expectations for the upcoming lesson (Brown & Green, 2019). It involves engaging students in a meaningful way, presenting the lesson's objectives and connecting the content to their real-world experiences. The next important skill is the explanation and exemplification of content. Effective teachers are adept at breaking down complex concepts into understandable parts, providing clear explanations, and using appropriate examples and analogies to enhance student understanding (Schneider et al., 2022).

The use of learning materials is another aspect of teaching skills (Bytyqi, 2017). Skillful teachers use a variety of instructional resources, such as visual aids, manipulatives, multimedia and technology tools to support student learning and engagement. They select and integrate relevant materials that cater to diverse learning styles and foster active participation. Lastly, the skill of lesson conclusion is crucial for summarising key points, reinforcing understanding, and connecting the lesson's content to broader concepts or future learning (Gayle et al., 2006). It involves providing a synthesis of the lesson, allowing students to reflect on their learning, and addressing any lingering questions or misconceptions. By honing these teaching skills, educators can effectively manage the learning process, create

engaging and meaningful learning experiences, and foster student success and achievement in the classroom.

2.2 Problem-based Learning

Generally, PBL is an instructional approach that offers students the opportunity to learn by actively engaging in the process of problem-solving. Scholars have provided definitions to exemplify how a class with PBL environment should be managed. For example, Hmelo-Silver (2004) defines PBL as a teaching method that allows students to acquire both content knowledge and thinking strategies through the experience of solving problems. Instead of being presented with pre-determined information, students are presented with a complex problem that lacks a single correct solution. Collaborating in groups, students identify the knowledge and skills they need to acquire in order to tackle the problem. They engage in self-directed learning (SDL) to acquire the necessary knowledge and then apply their newfound understanding to the problem at hand. Throughout this process, students reflect on their learning experiences and the effectiveness of the strategies employed. In PBL, the role of the teacher shifts to that of a facilitator who guides and supports the learning process rather than simply delivering information. According to Cho et al. (2015), PBL uses authentic problems as a catalyst for self-directed knowledge construction. This approach recognises that learning occurs as students work towards understanding and resolving a problem.

Barrows (1986) similarly emphasises that in PBL, the problem serves as the initial point of encounter in the learning process. The students are presented with a problem and engage in the process of acquiring knowledge and developing solutions collaboratively and individually. Teachers in PBL act as facilitators, guiding students through the learning journey and providing the necessary support to foster knowledge construction. Barrett (2017) defines PBL as a teaching method that presents students with problems and empowers them to construct knowledge collaboratively and individually in order to solve those problems. In this approach, students actively engage in the process of problem-solving, rather than passively receiving information. The teacher's role in PBL is that of a facilitator who guides and supports students throughout their learning journey. By presenting students with authentic problems, PBL promotes active learning, critical thinking and the development of problem-solving skills. Students work collaboratively, drawing on their prior knowledge, acquiring new knowledge through research and inquiry, and applying their understanding to propose solutions to the presented problems. Through this process, students take ownership of their learning and develop the skills necessary to address real-world challenges.

Therefore, it is evident that PBL is a teaching method that places students at the centre of the learning experience, allowing them to develop critical thinking, problem-solving skills and content knowledge through active engagement with authentic problems. Collaborative group work, SDL and reflection are key components of PBL, while teachers assume the role of facilitators, guiding students' learning and providing support as they navigate the complexities of problem-solving. From a theoretical point of view, Savery and Duffy (1995)

further explain that the PBL process aligns with the constructivist perspective. By engaging students in real-world problem-solving activities, PBL encourages them to construct their own knowledge and meaning through active inquiry, collaboration and reflection. This constructivist approach promotes deeper understanding and long-term retention of concepts, as students actively construct their knowledge based on their prior experiences, interactions and reflections. PBL thus not only develops students' learning management skills but also nurtures their ability to construct knowledge and meaning in a meaningful and authentic manner.

In terms of cognitivism, PBL activates students' cognitive processes, such as information processing, knowledge organisation and schema construction, as they grapple with complex problems and seek solutions (Rotgans & Schmidt, 2011). Collaborative learning is also inherent in PBL, as students work together in groups, sharing ideas, perspectives and expertise, which enhances their understanding and promotes social interaction and knowledge construction. Furthermore, PBL incorporates elements of connectivism, a learning theory that emphasises the importance of networked learning and leveraging technology to access and share information and collaborate with others (Sitti et al., 2013). In PBL, students can utilise digital resources, online communities and technology tools to gather information, communicate and collaborate, thereby expanding their learning network and leveraging collective intelligence. By encompassing these theories, PBL provides a holistic and comprehensive approach to learning that promotes active engagement, knowledge construction, social interaction and technological integration.

2.3 Potential of Problem-Based Learning in the Development of Learning Management Skills

It can be noted that PBL holds significant potential for the development of learning management skills among students (Barell, 2006; Boud & Feletti, 2013; Hung et al., 2019). PBL offers a unique and immersive learning experience that goes beyond the acquisition of content knowledge and fosters the development of crucial skills for effective learning management. By engaging students in authentic problem-solving scenarios, PBL provides opportunities to develop and refine various skills that are integral to effective learning management. Moreover, in PBL, students take an active role in identifying what they need to learn in order to solve the presented problem. This SDL process requires students to independently seek out relevant information, analyse and evaluate various resources, and integrate their findings to propose solutions. Through this experience, students develop skills in information literacy, critical thinking and resource management – all of which are essential components of effective learning management. Collaborative learning is another significant aspect of PBL that contributes to the development of learning management skills. Students work together in groups to analyse the problem, discuss possible solutions and collectively construct knowledge. Collaboration allows students to develop skills in communication, teamwork and negotiation, which are essential for managing group dynamics and facilitating effective learning environments. Furthermore, PBL provides a platform for students to develop skills in critical reflection and metacognition – key elements of effective learning management. Throughout the

problem-solving process, students engage in regular reflection on their learning experiences, their progress and the effectiveness of their strategies. They evaluate their understanding, identify areas for improvement and make adjustments accordingly. This reflective practice cultivates self-awareness, self-regulation, and the ability to make informed decisions about learning strategies, instructional approaches and assessment methods – all essential skills for effective learning management. However, it is important to acknowledge that PBL is not without its disadvantages and challenges. Implementing PBL effectively requires significant planning, resources and time. Moreover, it may not suit all learning environments or be suitable for every topic. In the current study, we employed PBL as a pedagogical strategy aimed at enhancing the learning management skills of mathematics education students, acknowledging both its potential benefits and the need to navigate its associated challenges in bridging the gap between theory and practice in the education field.

2.4 Previous Studies
Several studies (e.g., Akben, 2019; Bosica et al., 2021; Hadi & Izzah, 2021; Hursen, 2021; Koh & Chapman, 2019; Major & Mulvihill, 2017; Martin & Jamieson-Proctor, 2022) have investigated the implementation and effectiveness of PBL in various teacher education contexts, yielding diverse findings. Synthesising these studies, it becomes evident that PBL holds significant potential in enhancing pre-service teachers' knowledge and skills across various subject areas such as mathematics (Bosica et al., 2021; Koh & Chapman, 2019; Martin & Jamieson-Proctor, 2022), English (Hadi & Izzah, 2021), and teaching skills (Akben, 2019; Major & Mulvihill, 2017). Moreover, PBL has demonstrated efficacy in developing pre-service teachers' thinking skills, as evidenced in studies by Hadi and Izzah (2021) and Hursen (2021). While these previous studies offer valuable insights into the implementation, impact and perceptions of PBL in teacher education contexts, empirical evidence is needed to substantiate the effectiveness of PBL in teaching skills, as most prior research has primarily focused on students' perceptions of learning outcomes. Therefore, the present study aims to address this gap by employing an assessment method capable of identifying students' teaching skills in both the aspects of learning management plan design and plan implementation in the classroom. The study's objectives are to examine the effectiveness of PBL in developing mathematics education students' learning management skills and to assess their satisfaction with the PBL approach. This research not only contributes to the growing body of knowledge on the use of PBL in teacher education but also provides empirical evidence regarding its impact on the development of essential teaching skills, filling a critical void in the existing literature.

3. Methodology
3.1 Participants
The study involved a total of 30 mathematics education students enrolled in a public university in Thailand. These participants were selected from a larger pool of 96 students who were taking a learning management course. The sampling method employed for participant selection was cluster sampling, which involved dividing the students into clusters based on specific criteria and then randomly selecting participants from those clusters. This approach ensured representation from different groups within the student population. Regarding ethical

considerations, the study adhered to ethical guidelines and protocols to protect the rights and well-being of the participants. Informed consent was obtained from all participants, ensuring that they were fully aware of the study's objectives, procedures and potential risks or benefits before their participation. Confidentiality and anonymity were maintained throughout the study, with participant identities kept strictly confidential and data reported in aggregate form to prevent individual identification.

3.2 Instruments

3.2.1 Problem-based learning activities

The treatment used in this study was a set of class activities designed in PBL to teach learning management course. The activities included designing authentic problem scenarios where students were categorised into group and create real-world challenges in lesson design and teaching implementation to let them work collaboratively to find solutions; analysing exemplary lesson plans to identify key components of effective learning management; engaging in problem-solving simulations to address teaching challenges; collaborating on the design and implementation of lessons that incorporate learning management principles; and conducting reflective analyses of classroom challenges to develop potential solutions. For instance, they might be given a scenario where they had to manage a classroom with students of diverse learning abilities and behaviour. This scenario could simulate the challenges faced by teachers in actual classrooms. Students were then categorised into groups to collaboratively address these scenarios. For example, one group might focus on creating strategies to address disruptive behaviour, while another group worked on adapting lesson plans to accommodate different learning styles. Students analysed exemplary lesson plans that incorporated effective learning management strategies. They dissected these plans to identify key components such as classroom organisation, assessment techniques and engagement methods. Students then engaged in problem-solving simulations that mimicked real teaching challenges. For instance, they might role-play scenarios where they encountered student resistance to a particular topic or disruptive behaviour in the classroom, requiring them to develop strategies for effective resolution. Next, students collaborated on the design and implementation of lessons that incorporated learning management principles. For instance, they might work together to create a lesson plan that addressed the needs of diverse learners while maintaining a conducive learning environment. Lastly, after classroom challenges or simulations, students engaged in reflective analyses. They discussed and analysed the challenges they faced, shared potential solutions and considered how they could apply these insights to their future teaching practice.

These activities promoted problem-solving, critical thinking and collaboration while allowing students to apply theoretical knowledge, reflect on their practice, and develop practical skills necessary for effective learning management within the context of lesson design and teaching implementation.

3.2.2 Assessment of Learning Management Skills

An assessment form was developed to evaluate learning management skills using a holistic rubric rating scale ranging from 1 to 5. The assessment encompassed two main aspects: learning management design and teaching implementation. The learning management design aspect consisted of 19 assessment issues, totalling a maximum of 95 points, distributed across six topics, namely Components of Learning Management Plan, Learning Content / Key Concepts, Learning Objectives, Learning Process, Learning Materials / Learning Resources, and Assessment and Evaluation. The teaching implementation aspect comprised 14 assessment issues, with a maximum of 70 points, focusing on skills in Lesson Introduction, Explanation and Exemplification, Uses of Instructional Media and Summarising Lessons. The reliability of the learning management design assessment was tested using the Cronbach's coefficient, yielding a value of 0.82, while the teaching implementation assessment demonstrated a reliability coefficient of 0.84. The content validity of each assessment item was 0.5-1.0 tested by the process of index of item objective congruence (IOC).

3.2.3 Satisfaction Questionnaire

The questionnaire used a 5-point Likert scale with 10 items to measure participants' satisfaction with their learning experience in PBL and the development of learning management skills. The items focused on content related to satisfaction with the PBL approach and its effectiveness in fostering learning management skills. The index of IOC, a measure of item validity, ranged from 0.5 to 1.0, indicating good alignment between the items and the intended objectives. Furthermore, the questionnaire demonstrated high reliability, as evidenced by a Cronbach's coefficient of 0.87, suggesting internal consistency and reliability of the scale in measuring participants' satisfaction with their PBL-based learning experience and the development of learning management skills. The content validity of each assessment item was 0.5-1.0 tested by the process of index of IOC.

3.3 Data collection and data analysis

The data-collection process involved implementing the treatment, which consisted of using the PBL approach to develop learning management skills. Following the treatment, an assessment was conducted at the end of the intervention to evaluate the participants' learning management skills. Additionally, a questionnaire was administered to measure participants' satisfaction with the PBL experience and the development of their learning management skills.

For data analysis, descriptive statistics were employed to summarise and interpret the collected data. To determine the attainment of learning management skills, a one-sample t-test was used, comparing participants' scores to the pre-determined criterion of achieving 75% of the full mark.

4. Results

Table 1. Participants' performances after PBL activities

Learning management skills	Fullmark	Minimum	Maximum	Mean	S.D.	%
Learning management design	**95**	**76.00**	**82.00**	**77.90**	**2.32**	**82.00**
1) Components of Learning Management Plan	10	8.00	10.00	9.00	.53	90.00
2) Learning Content / Key Concepts	15	12.00	14.00	12.67	.71	84.44
3) Learning Objectives	15	13.00	15.00	14.43	.73	96.22
4) Learning Process	25	17.00	20.00	18.60	1.07	74.40
5) Learning Materials / Learning Resources	15	12.00	13.00	12.40	.50	82.67
6) Assessment and Evaluation	15	10.00	12.00	10.80	.85	72.00
Teaching Implementation	**70**	**56.00**	**59.00**	**56.90**	**1.18**	**81.29**
1) Skills in Lesson Introduction	20	15.00	19.00	17.33	1.15	86.67
2) Skills in Explanation and Exemplification	20	16.00	18.00	16.73	.74	83.67
3) Skills in Using Instructional Media	15	11.00	13.00	11.70	.70	78.00
4) Skills in Summarising Lessons	15	11.00	12.00	11.13	.35	74.22
Overall	**165**	**132.00**	**140.00**	**134.80**	**2.86**	**81.70**

The results of the study revealed that the implementation of PBL activities had a notable positive effect on the development of students' learning management skills. Notably, in the learning management design aspect, students achieved a commendable mean score of 77.90 (S.D. = 2.32), equating to 82% of the full mark. This demonstrated their high proficiency in crafting effective learning management plans. Similarly, in teaching implementation, students exhibited strong capabilities with a mean score of 56.90 (S.D. = 1.18) accounting for 81.29% of the full mark, showcasing their adeptness in executing these plans in the classroom. The overall mean score of 134.80 (S.D. = 2.86), accounting for 81.70%, further confirmed the efficacy of PBL in nurturing comprehensive learning management skills among the students. These findings highlight the significant impact of PBL in enhancing students' learning management abilities, underscoring its potential as an effective instructional approach in educational contexts.

Table 2. Effects of PBL on participants' learning management skills

Learning management skills	Full mark	Mean	S.D.	Comparative point (75%)	t-test	p
Learning management design	95	77.90	2.32	71.25	15.67*	.00
Teaching implementation	70	56.90	**1.18**	52.5	20.34*	.00
Overall	165	134.80	2.86	123.75	21.18*	.00

*p<0.05

The results further demonstrate that the students' learning management skills had indeed reached the expected level of proficiency. The one-sample t-test conducted on both learning management design ($\bar{x}$ = 77.90, S.D. = 2.32) and teaching implementation ($\bar{x}$ = 56.90, S.D. = 1.18) indicated that the students' performances in both aspects were significantly higher than the pre-determined criterion of achieving 75% of the full mark. This statistical analysis confirms that the students' learning management skills had developed to a level that exceeded the targeted proficiency level, supporting the effectiveness of the PBL intervention in facilitating their learning management abilities. The results highlight the successful achievement of the study's objectives, as the students' performances surpassed the expected standard, demonstrating the substantial impact of PBL in enhancing their learning management skills.

Table 3. Participants' satisfaction

Items	$\bar{x}$	S.D.	Interpretation
1. Learning activities promote problem-solving skills.	4.73	0.45	Very satisfied
2. Learning activities help students understand the content of learning management classes.	4.47	0.63	satisfied
3. Learning activities enable students to demonstrate mathematical proofs.	4.27	0.78	satisfied
4. Learning activities facilitate the design of mathematics teaching plans for primary/secondary schools.	4.47	0.68	satisfied
5. Learning activities instil confidence in teaching mathematics.	4.50	0.63	Very satisfied
6. Learning activities encourage students to exchange knowledge with their peers.	4.67	0.61	Very satisfied
7. Learning activities train students to work collaboratively with others.	4.73	0.64	Very satisfied
8. Learning activities help students develop their expressive abilities.	4.50	0.73	Very satisfied
9. Learning activities empower students to express their opinions in the classroom.	4.60	0.72	Very satisfied
10. Learning activities are fun and engaging.	4.50	0.82	Very satisfied
Overall	**4.54**	**0.48**	**Very satisfied**

The results revealed that participants had a highly satisfying learning experience with the PBL activities overall ($\bar{x}$ = 4.54, S.D. = 0.48). They strongly agreed that the

PBL approach improved problem-solving skills, deepened their understanding of the content, and enabled them to demonstrate mathematical proofs. Participants also found the PBL activities effective in guiding them to design mathematics teaching plans and boosting their confidence in teaching. Additionally, they appreciated the opportunities for peer knowledge exchange, collaborative work and expressing themselves confidently in the classroom. Overall, the participants highly valued the engaging and enjoyable nature of the PBL learning activities, emphasising the effectiveness of the approach in developing their learning management skills and providing a positive learning environment.

5. Discussion

The results of this study provide compelling evidence that PBL is highly effective in the design of a learning management skills course. Not only did the implementation of PBL activities successfully develop students' learning management skills, but it also fostered a satisfying and engaging learning experience for them. These findings align with previous studies (e.g., Akben, 2019; Bosica et al., 2021; Hadi & Izzah, 2021; Hursen, 2021; Koh & Chapman, 2019; Major & Mulvihill, 2017; Martin & Jamieson-Proctor, 2022), highlighting the numerous benefits of incorporating PBL into teacher education contexts.

The success of PBL in developing participants' learning management skills can be attributed to its strong emphasis on real-world problem-solving. Barrett (2017) emphasised that by presenting students with authentic and complex problems related to educational contexts, PBL immerses them in practical challenges they may encounter in their future teaching careers. Moreover, through collaborative group work, students not only develop essential problem-solving skills but also cultivate a collaborative and dynamic learning environment. This approach encourages active engagement and interaction among peers, fostering a supportive atmosphere where students can freely exchange ideas, challenge each other's perspectives and collectively arrive at innovative solutions to real-world challenges. The collaborative nature of PBL promotes critical thinking, creativity and resourcefulness as students learn from each other's diverse insights and experiences, thereby enhancing their ability to tackle the complex issues they may encounter in their future roles as educators (Rotgans & Schmidt, 2011). Furthermore, class presentations provide students with an opportunity to showcase their solutions, fostering effective communication and enhancing their ability to articulate their ideas with confidence (Fonteijn & Dolmans, 2019).

The participants' high satisfaction with the PBL approach can be linked to the authentic learning experiences it offers. As they actively engage in problem-solving and apply their knowledge in real-world contexts, learners can clearly see the direct relevance of the skills they acquire in the classroom to their future careers as educators. This strong connection between classroom learning and real-world applications contributes significantly to a sense of fulfilment and readiness for their professional journey. These findings align with Noreen et al.'s (2019) research, which suggests that an authentic learning environment is positively correlated with learning satisfaction.

However, it is important to delve deeper into the existing literature to explore any discrepancies or alternative interpretations of these findings. Acknowledging potential limitations or areas where the results may not align with prior research can enhance the overall critical analysis of this study and provide a more comprehensive understanding of its implications.

6. Conclusion

In conclusion, this study demonstrates the effectiveness of PBL activities in the development of mathematics education students' learning management skills, encompassing learning management design and teaching implementation. Additionally, the study explored participants' satisfaction with the PBL activities, which was found to be remarkably high. The positive impact of PBL in enhancing learning management skills and fostering a fulfilling learning experience has significant implications for both academic and pedagogical contexts.

Academically, the findings contribute valuable insights to the field of teacher education, emphasising the importance of employing innovative instructional approaches like PBL to develop students' practical skills for their future teaching careers. The study's positive outcomes add further evidence to support the incorporation of PBL in various teacher education courses, helping to bridge the gap between theoretical knowledge and real-world application.

Pedagogically, the success of PBL in fostering collaborative problem-solving and critical thinking skills suggests that educators should consider integrating similar active learning strategies into their instructional practices. By encouraging group work and problem-solving activities, instructors can create dynamic and engaging learning environments that empower students to become more self-directed, resourceful and adept at addressing complex challenges.

From a policy perspective, the study underscores the significance of infusing real-world problems and authentic learning experiences into all teacher education classes. Policymakers should consider incorporating PBL and similar experiential learning approaches as standard components of teacher education curricula. This proactive measure can help ensure that future educators are well-prepared to meet the demands of their profession and make meaningful contributions to the educational landscape.

For future studies, researchers can delve deeper into the qualitative aspects of the learning experiences by incorporating interviews or focus group discussions with participants. Qualitative data can provide richer insights into participants' perceptions and experiences, further enhancing the validity and understanding of the study's findings. Additionally, investigating the long-term effects of PBL on students' teaching practices and career development would be beneficial in assessing the lasting impact of this instructional approach.

Despite the promising outcomes, the study is not without limitations. The reliance on quantitative data alone may limit the exploration of participants' nuanced experiences. By adopting mixed methods approaches, future studies can complement the quantitative data with qualitative insights, providing a more comprehensive understanding of the effects of PBL on learning management

skills development. Overall, this study contributes valuable evidence supporting the effectiveness of PBL in teacher education, encouraging the integration of real-world problem-solving experiences to better prepare aspiring educators for their future roles.

Acknowledgements

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