

Research Article

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Developing Pre-service Teachers' Mathematics Teaching Skills and Attitude through Project-Based Learning and Reflective Learning

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Abstract

Background/purpose. This study aimed to enhance the teaching skills and professional attitudes toward teaching pre-service teachers through the integration of Project-Based Learning (PjBL) by teaching one-on-one and reflective learning.

Materials/methods. The participants were 29 second-year mathematics pre-service teachers enrolled in the Practicum 2 course. The research methodology was an Experimental-Intervention Design mixed method. The quantitative data were the pre- and post-tests of a self-assessment of instructional skills and an attitude toward the teaching profession, and the qualitative data were check tasks, interviews, and self-reflection.

Results. Results revealed statistically significant improvements in teaching skills and attitude domains ($p < .05$), and qualitative findings showed increased confidence, adaptability, and professional motivation.

Conclusion. This study contributes to teacher education by demonstrating that combining PjBL with Reflective Learning effectively supports individualized instruction development.

1. Introduction

During years of teaching practicum courses for pre-service teachers, we have consistently observed that many students struggle with real classroom scenarios requiring individualized instructional approaches. Despite having completed coursework on lesson planning and classroom management, a number of students express uncertainty and hesitation when working one-on-one with learners—whether to provide clarification, offer remediation, or respond to advanced learners seeking deeper engagement. These situations frequently arise in school placements, yet students often feel unprepared to handle them effectively. This recurring challenge prompted me to reflect more deeply on how our teacher preparation courses are equipping future educators for personalized instruction. It became evident that there is a gap between theoretical understanding and practical application of individualized teaching strategies, which led to the development of this study.

Individualized instruction is a fundamental competency for all instructors (Karadag, 2010; Malinović-Jovanović & Zdravković, 2018). Throughout a teacher's career, circumstances for individualized instruction often occur. For instance, a student experiencing shyness or uncertainty over a course may pursue clarification post-class. Similarly, students exhibiting a strong interest in a subject may seek individual consultations with the teacher for enhanced comprehension. Likewise, students with learning difficulties, including learning impairments (LD), may greatly benefit from personalized attention (United States Department of Education, 2018). These instances underscore the significance of a teacher's capacity to provide successful individualized teaching.

Individualized instruction is also vital in mathematics education, especially in mathematics problem-solving questions (Kochmanski, 2022). Resolving mathematical issues frequently necessitates individualized elucidation, motivation, and direction adapted to a student's unique cognitive approach (Fraser & Hasan, 2019). An adept one-on-one educator may discern learners' misconceptions, offer suitable scaffolding, and promote autonomous thought—challenging factors to accomplish in bigger group environments (Thanheiser & Melhuish, 2023). Consequently, teachers' proficiency in delivering individualized mathematics instruction is essential for equipping them for practical teaching scenarios.

Therefore, it is essential to provide student teachers with these sets of skills, as these competences are advantageous during their teacher education and throughout their professional careers. Through this growth, they acquire the ability to recognize and address individual differences, implement suitable pedagogical practices, and improve significant teacher-student relationships (Joseph et al., 2013). Moreover, individualized teaching experiences enhance student instructors' confidence in addressing varied learning requirements and refine their communication abilities by providing explanations to meet the needs of each student.

Nonetheless, establishing proficient one-on-one instructional abilities is a complex task (Gibbs, 2023; Rashid & Wong, 2023). To provide significant personalized education, student instructors must cultivate a variety of fundamental pedagogical qualities, including designing suitable learning activities, administering and conveying instruction, having the aptitude to develop and utilize instructional media, and assessing and evaluating student learning outcomes precisely (Gravells, 2017). In contrast to whole-classroom training, which allows for generic instructional design, one-on-one teaching necessitates thorough attention. Educators must modify their techniques instantaneously according to a student's feedback and comprehension level. This degree of personalization requires both pedagogical expertise and the adaptability to customize training for specific learners (Normoyle, 2023). In addition to technical teaching skills, the development of a positive professional attitude is also crucial. Pre-service teachers must demonstrate patience,

empathy, and a genuine willingness to support individual learning needs—traits that are essential for building trust and meaningful learning in one-on-one settings (Hürsen, 2012).

Project-based learning (PjBL) is acknowledged as an effective method in teacher education (Krajcik & Shin, 2014; Thomas, 2000). Permitting student teachers to undertake projects aimed at promoting certain pedagogical abilities is advantageous as it is beneficial for active involvement, accountability, and practical application (Poonputta, 2023; Poonputta & Sarnkong, 2024). Moreover, designing, executing, and reflecting on a project make pre-service teachers acquire profound insights about their learning and teaching methodologies (Alrajeh, 2020). Therefore, in developing one-on-one teaching ability, project-based learning (PjBL) provides them with an opportunity to investigate authentic teaching situations, create lesson plans, and engage directly with students. In this circumstance, practical experience, critical thinking, pedagogical knowledge, and adaptation of teaching methodologies are promoted to address the distinct requirements of individual students.

A pedagogical method that can be effectively combined with Project-Based Learning is Reflective Learning. Schön (1983) defines reflective learning as the process wherein learners critically analyze their experiences, assess their actions, and apply those insights to enhance future performance. In teacher education, this refers to prompting pre-service teachers to engage in active reflection on their pedagogical experiences, decision-making processes, and student reactions (McGarr, 2021; Suphasri & Chinokul, 2021). In Project-Based Learning (PjBL), pre-service teachers could undertake a one-on-one teaching project followed by participation in organized reflecting activities, such as composing teaching journals, sharing insights in group discussions, or completing reflective reports. This has the potential to enhance their practical abilities and enriches their comprehension of the efficacy and rationale behind specific instructional strategies. As such, metacognition, teaching progress, and a growth mindset can be facilitated.

whereas individualized teaching tactics like one-on-one instruction are crucial for effective pedagogy, they are also intricate to formulate. Pre-service teachers must develop many competencies, including lesson design, instructional delivery, media utilization, and assessment skills. In the context of this study, project-based Learning offers a pragmatic and stimulating framework for cultivating these abilities via real-world application. The process is significantly enhanced when combined with Reflective Learning, enabling student instructors to derive insights from their experiences and perpetually refine their skills. The pair presents a viable avenue for equipping pre-service teachers to proficiently and confidently provide one-on-one teaching in mathematics education.

2. Literature Review

2.1. Individual Instruction

Individual instruction, also known as one-on-one teaching, referred to as individualized or adaptive instruction, emphasizes customizing teaching and learning experiences to address the distinct needs, strengths, and interests of each learner (Karadag, 2010). It diverges from conventional, teacher-centric pedagogy by prioritizing student-centered methodologies and individualized learning. Scholars (Karadag, 2010; Kochmanski, 2022; Malinović-Jovanović & Zdravković, 2018) have presented core components that support the effectiveness of individual instruction including personalized learning, wherein instruction is designed to align with each learner's pace and style; student-centred learning, which promotes active engagement and ownership of the learning process; assessment-driven decision-making, utilizing continuous evaluations to guide instruction; and flexibility, permitting dynamic modifications of teaching methods and materials. At its core, effective individual instruction depends on the educator's capacity to comprehend students profoundly, provide adaptive activities, and sustain a classroom atmosphere that empowers independence (Merrill, 1994). Research (Adams et al., 2023;

Kochmanski, 2022) has emphasized its advantages, including heightened motivation, profound learning, improved self-esteem, and augmented educational equity, especially for those requiring specialized assistance.

From a theoretical point of view, learning is perceived as an internal process that differs among individuals which signifies the necessity to consider students' past knowledge, working memory capacity, and processing speed (Bleistein & Lewis, 2015). In constructivist theories, especially those of Piaget and Vygotsky, who emphasize the significance of learners actively generating knowledge via experience and interaction, student-centered environments in which educators serve as facilitators play a great role in directing students in their exploration of knowledge in significant and individualized manners. Considering Zone of Proximal Development (ZPD) (Vygotsky, 1987), individualized instruction enables educators to offer rapid and customized scaffolding to facilitate student advancement just beyond their existing capabilities.

However, possible challenges in mathematics education could be noted. Mathematics requires precise conceptual understanding, and providing one-on-one support to meet each student's specific misconceptions or gaps can be demanding for teachers, especially in large classrooms (Bleistein & Lewis, 2015). Thus, creating diverse pathways through content, designing assignments to different ability levels, and offering immediate evaluation and feedback require considerable effort, expertise, and resources. Moreover, educators must possess proficiency in many instructional methodologies, including differentiated instruction, mastery learning, and peer tutoring, as well as the ability to incorporate technology to facilitate personalized learning adeptly. In mathematics education, where students frequently encounter fear or diminished confidence, the capacity to deliver adaptive and supportive individualized instruction becomes increasingly essential.

2.2 Project-Based Learning (PjBL)

The fundamental element that makes Project-Based Learning (PjBL) beneficial for teacher education is its capacity to involve pre-service teachers in the active creation of a project designed to address authentic challenges they are likely to face in their prospective teaching careers (Arora et al., 2017; Boss & Larmer, 2018; Krajcik & Shin, 2014). This problem-solving perspective is fundamental to teacher preparation and embodies the essential idea of Project-Based Learning (PjBL) as an educational methodology. In the design and execution of a project, learners assume responsibility for their educational journey by recognizing a problem, devising solutions, executing actions, and evaluating results (Krajcik & Shin, 2014). This corresponds with cognitive learning theories that underscore active involvement, problem-solving, and knowledge creation as vital components of meaningful learning (Boss & Larmer, 2018). Furthermore, when learners dedicate substantial effort to a project that holds personal and professional significance, they are more inclined to cultivate favorable views toward the subject—in this instance, teaching. Through the development of a one-on-one instructional project, pre-service teachers acquire significant experience throughout all phases of the teaching process, encompassing student selection, creating lesson planning, instructional delivery, learning assessment, and real-time adjustments. These experiences support practical teaching abilities while enhancing professional identity and confidence in addressing varied learner needs.

Moreover, empirical evidence from recent studies (Al-Busaidi & Al-Seyabi, 2021; Alrajeh, 2020; DeCoito & Briona, 2023; Molina-Torres, 2022; Rahmawati et al., 2020; Tsybulsky & Muchnik-Rozanov, 2023) also highlights the benefits of Project-Based Learning (PjBL) in teacher education which show its impact on various dimensions of pre-service teachers' professional development. For instance, Al-Busaidi and Al-Seyabi (2021), in a study conducted within an Omani EFL teacher education program, found that PjBL significantly contributed to student-teachers' professional growth as it enhanced their reflective thinking, collaboration, and instructional design skills. Similarly, Alrajeh (2020)

emphasized that PjBL supports the development of critical thinking, creativity, and communication among pre-service teachers. DeCoito and Briona (2023) showed that incorporating digital technologies into PjBL helped STEM pre-service teachers improve an entrepreneurial mindset alongside pedagogical skills. Molina-Torres (2022) found that PjBL positively influenced primary education pre-service teachers' ability to connect theory with practice and their confidence in planning and implementing student-centered instruction. Rahmawati et al. (2020) concluded that technology-integrated PjBL enhances pre-service teachers' technological pedagogical content knowledge (TPACK), engagement, and readiness for real-world teaching. Additionally, Tsybulsky and Muchnik-Rozanov (2023) reported that a PjBL course framed as a pedagogy of practice significantly contributed to the development of pre-service teachers' professional identity by allowing them to experience authentic teaching tasks in a supportive environment.

2.3. Reflective Learning

Reflective learning fundamentally stresses the establishment of critical thinking regarding one's own experiences, behaviors, and decisions to enhance understanding and promote ongoing growth in subject matters. Therefore, it is essential in teacher education to develop professional competence since it prompts pre-service teachers to sharpen their teaching approaches, evaluate their efficacy, and implement informed modifications. Grounded in constructivist and experiential learning theories, reflective learning perceives knowledge as actively generated via individual experience and critical analysis. Schön (1983) posits that reflective practitioners partake in both reflection-in-action (during instruction) and reflection-on-action (post-instruction), facilitating significant learning and professional development. Contemplating their pedagogical decisions and student reactions enables pre-service teachers to cultivate self-awareness, autonomy, and the capacity to modify their methods to more effectively address learners' needs. Reflective learning is especially effective when combined with active teaching experiences, since it offers a systematic approach for student instructors to comprehend their experiences and use new ideas in future teaching contexts.

Previous studies have emphasized the significant role of reflective learning in enhancing pre-service teachers' professional development and classroom readiness. For example, McGarr (2021) showed that reflective activities prepared with immersive teaching experiences—can lead to deeper behavioural awareness and improved decision-making among pre-service teachers. The study demonstrates that structured reflection following simulated practice enhances both confidence and pedagogical competence. In a broader context, Torres-Cladera et al. (2021) found that reflective learning plays a critical role in shaping pre-service teachers' professional identities in terms of a sense of purpose and professional self-awareness. Suphasri and Chinokul (2021) explore the evolving concept and role of reflective practice in teacher education, emphasizing its growing reputation as a marker of professional competence. The authors urged that reflective practice has changed over time and technology can be used to support and enhance reflective practice.

2.4. Research Gaps and Study Potential Contributions

Therefore, existing research indicates that Project-Based Learning (PjBL) and Reflective Learning effectively contribute to teacher development, particularly when preparing pre-service teachers who are capable of independently managing projects and critically integrating feedback. However, while previous studies on PjBL in teacher education have largely focused on enhancing traditional, whole-class instruction—addressing conventional teaching duties, the specific impact of PjBL on individual teaching remains underexplored. Likewise, reflective learning has often been applied alongside other active, problem-based approaches such as virtual simulations and professional development workshops, rather than in combination with PjBL to target individualized instruction. Additionally, beyond technical teaching skills, the development of positive attitudes toward teaching is a crucial component of teacher preparation. Pre-service teachers who develop confidence, motivation, and a

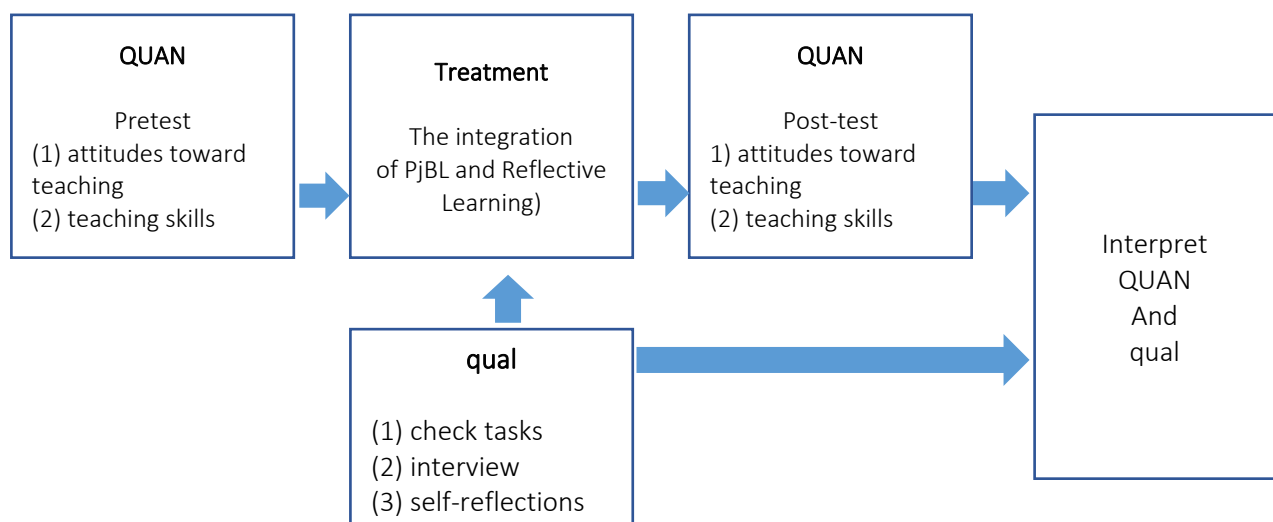
sense of professional responsibility are more likely to succeed in their future roles, especially in individualized instructional settings where empathy, patience, and adaptability are essential. This study aims to bridge these gaps by examining the effects of PjBL on developing one-on-one teaching skills, thereby expanding the scope of teacher education research and demonstrating that reflective learning can be effectively integrated with PjBL to enhance individualized teaching competence. Therefore, the current study integrated Project-Based Learning and Reflective Learning to develop the individual instruction skills of mathematics pre-service teachers. The purposes of the studies were 1) to examine the effectiveness of project-based learning integrated with reflective learning on mathematics pre-service teachers' one-on-one teaching skills and 2) to examine the effectiveness of project-based learning integrated with reflective learning on mathematics pre-service teachers' attitudes toward teaching.

3. Methodology

3.1. Research Design

This study employed an Experimental-Intervention Design mixed method approach combined, which was adapted from the embedded design of Buasonte (2011), Creswell (2015), and Creswell & Plano Clark (2018). Each phase involved pre-service teachers planning and conducting one-on-one instructional activities as part of a project-based learning experience, followed by reflective learning activities to evaluate and improve their teaching practices.

The quantitative aspect of the research utilized a one-group pretest-posttest design to examine changes in participants' one-on-one instructional skills and attitudes toward teaching. Before using the treatment, participants completed pretest assessments. Throughout the six phase, participants engaged in project-based learning tasks integrated with structured reflection, and intervention the qualitative data were check tasks, interview and self-reflections. After the final cycle, the same instruments were administered as post-tests to evaluate growth and outcomes. (Picture 1)



QUAN = Data collection with a focus on quantitative research is main method

qual = Data collection with a focus on qualitative research is a secondary method to support quantitative research

Figure 1. Research Design: Experimental-Intervention Design Mixed Method

(adapted from Buasonte (2011), Creswell (2015), and Creswell & Plano Clark (2018))

3.2. Participants

The participants in this study were second-year pre-service teachers enrolled in the Bachelor of Education program, specifically those taking the course 0560 201 Practicum 2 during the academic year. The population consisted of students from 19 class sections across nine subject areas. Using cluster random sampling, with subject area as the unit of randomization, a single classroom of 29 second-year pre-service mathematics teachers from Class Section 11 was selected as the sample group. This particular course was chosen because it plays a pivotal role in preparing pre-service teachers with foundational teaching skills prior to their school-based teaching practicum. Moreover, the researcher was the course instructor and had previously observed that students often failed to meet course objectives. Past cohorts demonstrated insufficient skills in lesson planning, instructional activity design, teaching material development, and assessment. Additionally, many students lacked teaching confidence and displayed low attitudes toward the teaching profession. These challenges formed the rationale for conducting this study. Given the experimental nature of the research and the need to control variables, only one classroom was selected for the intervention, aligning with the principles of cluster random sampling.

3.3 Research Instruments

3.3.1. Project-Based Learning (PjBL) Integrated with Reflective Learning Management Plan

The instructional tool implemented in this study was a learning management plan based on Project-Based Learning (PjBL) integrated with Reflective Learning, in a four-step plan, act, present, and reflect process, provided. This plan guided participants through six phases, each designed to enhance their ability to teach mathematics through one-on-one instruction. As part of the project, each participant was required to independently select a student as a case study and develop a personalized instructional plan to address that student's learning needs. In each cycle, participants engaged in the following key activities: (1) Lesson Planning – analyzing student needs and designing a short-form lesson plan tailored to those needs, (2) Instructional Delivery - conducting one-on-one teaching sessions using methods aligned with the plan, (3) Instructional Media Design – developing or selecting appropriate teaching aids, whether handmade or technology-based, to support individualized learning, and (4) Assessment and Evaluation – creating tools such as quizzes, exercises, or rubrics to measure learning outcomes and student satisfaction. Following each round, participants engaged in Reflective Learning sessions, where they analyzed their teaching experiences, identified areas for improvement, and documented their reflections in the form of reports, journals, or presentations. This process was repeated across all six phase, allowing for continuous improvement and deepened pedagogical understanding.

3.3.2. One-on-One Instructional Skills Self-Assessment

This self-assessment instrument was used by participants to evaluate their instructional skills based on their self-perception before and after the intervention. It consists of 40 items, divided into four components including lesson planning, instructional delivery, instructional media development and use, and assessment and evaluation, with 10 items per component. The content validity of the instrument was reviewed by three experts, and all items received an Item-Content Validity Index (I-CVI) of 1.00. The instrument was piloted with second-year pre-service teachers from Class Section 13, the same group used for the tryout of the attitude questionnaire. Item discrimination values were analyzed using the Item-Total Correlation method, and all items showed statistically significant discrimination ($r=0.31-0.82$) at the .05 level. The overall reliability coefficient for the questionnaire was 0.95.

3.3.3. Attitude Toward the Teaching Profession Questionnaire

This instrument consisted of 30 items divided into three components: (1) Cognitive – referring to beliefs and understanding about the teaching profession, (2) Affective – capturing emotional reactions and interest in teaching, and (3) Behavioral – reflecting tendencies and intentions toward professional behaviors such as responsibility, compassion, and ethical conduct. The questionnaire was validated by three experts, with all items achieving an Item-Content Validity Index (I-CVI) of 1.00 and a Scale-level Content Validity Index (S-CVI) of 1.00, indicating high content validity (Polit & Beck, 2006). A tryout with a similar group (Class Section 13) resulted in appropriate item discrimination indices ($r = 0.31-0.81$) and the overall reliability coefficient (0.93).

3.4. Data Collection

Data collection was conducted over a 16-week semester, aligned with the implementation of the instructional intervention based on the six phase. The activities were structured in six phases, with data collected both during and after each phase using both quantitative and qualitative instruments.

Phase 1 (Weeks 1–2): Classroom Observation and Case Study Selection

At the beginning of the study, pre-service teachers completed two pre-assessment instruments: the One-on-One Instructional Skills Self-Assessment and the Attitude Toward the Teaching Profession Questionnaire, evaluating their self-perceived teaching competencies and attitudes prior to the intervention. Following this, participants were assigned to observe classrooms at their internship schools and consult with mentor teachers to select an individual student as a case study. This process aimed to familiarize pre-service teachers with real classroom contexts and help them identify learners who would benefit from individualized instruction. After completing this phase, participants reflected on their observation and selection process, generating the first set of reflective learning data.

Phase 2 (Weeks 3–4): Problem-Solving Planning

Participants developed individualized work plans and instructional approaches tailored to their case study students. These plans were presented to the course instructor for feedback and revised accordingly. Reflective notes were collected to capture participants' learning and response to the planning process.

Phase 3 (Weeks 5–6): Development of Instructional Materials and Assessment Tools

Participants created short-form lesson plans and designed instructional materials, including both paper-based and online exercises, quizzes, and student satisfaction questionnaires. These materials were submitted for instructor review and refined based on suggestions. Reflections were recorded on the process of designing and adapting materials.

Phase 4 (Weeks 5–8): Permission and Communication

During this phase, participants collaborated with their instructor to prepare official documents seeking permission from schools and parents to conduct the one-on-one instruction project. Students delivered the documents and explained the case study plan to parents and school administrators. Only upon receiving consent could the project proceed. Any challenges faced were discussed with the instructor, and reflective entries were written to document the experience.

Phase 5 (Weeks 9–11): Implementation of One-on-One Teaching

Pre-service teachers carried out their case study projects over three weeks, with a minimum of six teaching sessions per student. Instruction was delivered either online or onsite, including weekends or after school. Teachers were required to create a Google Classroom for communication and content delivery. After each session, participants completed reflective journals. When problems arose, they consulted with their instructor for guidance and support.

Phase 6 (Weeks 12–15): Final Reporting and Presentation

In the final phase, students compiled reports on their case study teaching outcomes using instructor-provided templates. They presented their findings using Canva or PowerPoint and submitted their written reports. Reflection sessions followed the presentations, capturing final insights and overall learning outcomes.

Post-Intervention Assessment (Week 16):

At the end of the project, all participants completed two quantitative instruments: the Attitude Toward the Teaching Profession Questionnaire and the One-on-One Instructional Skills Self-Assessment.

3.5. Data Analysis

The quantitative analysis uses the mean score, standard deviation, and a paired sample t-test, and the qualitative analysis uses content analysis.

4. Results

The results revealed a statistically significant improvement in all areas of participants' one-on-one teaching skills after participating in the project-based learning integrated with reflective learning intervention. Paired-sample t-tests indicated significant gains in lesson planning ($M = 4.68$, $SD = 0.34$) compared to pre-intervention scores ($M = 4.26$, $SD = 0.38$), $t(28) = 4.68$, $p < .05$; instructional delivery ($M = 4.69$, $SD = 0.36$) vs. ($M = 4.18$, $SD = 0.39$), $t(28) = 4.69$, $p < .05$; instructional media development and use ($M = 4.70$, $SD = 0.32$) vs. ($M = 4.18$, $SD = 0.44$), $t(28) = 4.70$, $p < .05$; and assessment and evaluation ($M = 4.78$, $SD = 0.29$) vs. ($M = 4.18$, $SD = 0.43$), $t(28) = 4.78$, $p < .05$. Overall, the total mean score improved from 4.20 ($SD = 0.36$) to 4.71 ($SD = 0.30$), with a significant mean difference of 0.51, $t(28) = 4.71$, $p < .05$. These results demonstrate that the intervention effectively enhanced pre-service teachers' one-on-one instructional skills across all evaluated dimensions. (Table 1).

Table 1. The Participants' One-on-One Teaching Skills Before and After the Implementation of the Learning Management

One-on-one teaching skills	Post		Pre		Mean difference	t-test	sig
	Mean	SD	Mean	SD			
1. Lesson Planning	4.68	0.34	4.26	0.38	0.42	4.68	.00*
2. Instructional delivery	4.69	0.36	4.18	0.39	0.51	4.69	.00*
3. Instructional media development and use	4.70	0.32	4.18	0.44	0.52	4.70	.00*
4. Assessment and evaluation	4.78	0.29	4.18	0.43	0.60	4.78	.00*
Overall	4.71	0.30	4.20	0.36	0.51	4.71	.00*

* $p < .05$

Table 1 presents the participants' one-on-one teaching skills before and after the implementation of the learning management. The findings revealed significant improvements in participants' attitudes toward the teaching profession following the intervention. In the cognitive domain, the post-intervention scores ($M = 4.94$, $SD = 0.09$) were significantly higher than the pre-intervention scores ($M = 4.24$, $SD = 0.31$), with a mean difference of 0.70, $t(28) = 12.37$, $p < .05$. In the affective domain, participants' attitudes improved from pre-intervention ($M = 4.18$, $SD = 0.40$) to

post-intervention ($M = 4.92$, $SD = 0.15$), with a mean difference of 0.74, $t(28) = 10.70$, $p < .05$. For the behavioural domain, the scores increased from ($M = 4.18$, $SD = 0.36$) to ($M = 4.86$, $SD = 0.21$), with a mean difference of 0.68, $t(28) = 8.19$, $p < .05$. Overall, participants' attitudes significantly improved from pre-intervention ($M = 4.20$, $SD = 0.32$) to post-intervention ($M = 4.91$, $SD = 0.11$), with a mean difference of 0.71, $t(28) = 12.32$, $p < .05$. These results suggest that the integration of project-based learning and reflective learning had a substantial positive impact on pre-service teachers' attitudes in all measured domains as shown in table 2.

Table 2. Participants' Attitudes Toward Teaching Profession Before and After the Implementation of the Learning Management

Attitudes toward Teaching profession	Post		Pre		Mean difference	t-test	sig
	Mean	SD	Mean	SD			
Cognitive domain	4.94	0.09	4.24	0.31	0.70	12.37	.00*
Affective domain	4.92	0.15	4.18	0.40	0.74	10.70	.00*
Behavioural domain	4.86	0.21	4.18	0.36	0.68	8.19	.00*
Overall	4.91	0.11	4.20	0.32	0.71	12.32	.00*

* $p < 0.05$

In addition to the quantitative findings, this study also examined the qualitative aspects of pre-service teachers' development through documentation and reflection gathered across the six phase. These phases, structured around Project-Based Learning (PjBL) integrated with Reflective Learning, in a four-step plan, action, present, and reflect process, provided rich insights into how participants engaged with real classroom situations, made instructional decisions, and responded to feedback throughout the intervention. The data for Phases 1–6 are presented in Table 3–8.

Table 3. Phase 1: Classroom Observation and Case Study Selection

Plan	Pre-service teachers selected a school where they would observe mathematics instruction at the basic education level (Grades 1–12). They scheduled observation dates and consulted with the mathematics teacher or mentor teacher to receive guidance in selecting a case study student.
Action	1. The pre-service teachers observed mathematics instruction in classrooms over the course of 1–2 weeks. 2. They selected a student who exhibited learning difficulties in mathematics and showed interest in receiving additional support.
Present	Each pre-service teacher recorded the following information: (1) the student's name, school, phone number, and email address, (2) the name and contact information of the student's parent or guardian, (3) the content area the student was interested in, confused about, or struggling with—this could be current grade-level content or foundational content from previous years. The information was submitted via Google Classroom and presented in class.

Reflect	Some participants reflected on challenges encountered during this phase and collaboratively explored possible solutions. Examples included: Problem 1: The observation period lasted one week, but mathematics instruction was scheduled for only three hours per week. On the actual observation day, only one hour of instruction was available, making it difficult to identify students with genuine learning difficulties. Observations were mostly limited to behavioural issues such as talking in class, not answering questions, or being disengaged. Solution 1: Request assistance from the mathematics teacher in identifying a student who struggles with mathematics learning. Problem 2: Some students with mathematics learning difficulties were unwilling to receive extra instruction because they lived more than 20 kilometres from the school and relied on school transportation. Staying after school for additional help would prevent them from catching the bus home on time. Solution 2: Two possible approaches were suggested: (1) Replace the student with another one recommended by the mathematics teacher. (2) Keep the same student but schedule sessions during lunchtime (after meals), homeroom periods, or designated learning extension periods during the regular school day.
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Table 4. Phase 2: Problem-Solving Planning

Plan	Participants design learning management by telling details; 1. The date and time the learning activity would be conducted 2. The specific content to be taught 3. The learning objectives 4. The instructional media to be used 5. The assessment and evaluation tools 6. The assessment criteria 7. The location of instruction (onsite with a specified venue or online) Participants submitted their plans through Google Classroom and presented them during class. Based on the review and discussion, it was found that most pre-service teachers were able to clearly and accurately determine three components: (1) the date and time for the instructional activity, (2) the content to be taught, and (3) the location of instruction. However, challenges were observed in the remaining four components. Many students struggled with writing learning objectives in behavioural terms. In addition, instructional media selection was limited—most initially chose only the textbook as a teaching aid. Therefore, they were encouraged to design additional materials such as (1) knowledge sheets and (2) exercises in both paper and digital formats (e.g., mobile applications). Moreover, the assessment tools chosen often did not align with the learning objectives, and assessment criteria were either
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unclear or incomplete. These challenges were addressed through classroom feedback and reflective discussion, helping pre-service teachers revise and improve their instructional designs in preparation for actual teaching.

Action	Pre-service teachers designed their learning plans according to the 7-item template.
Present	They submitted their plans via Google Classroom and presented them in class.
Reflect	1. Pre-service teachers were able to specify 3 items correctly: 1.1 Date and time of the instructional activity 1.2 Content to be taught to the student 1.3 Location of instruction (onsite with specified venue / online) 2. Pre-service teachers were unable to provide detailed planning for 4 items: 2.1 Learning objectives – they were not yet able to write objectives in behavioural terms 2.2 Instructional media – most selected only the textbook, so they were asked to design: 1) Knowledge sheets 2) Exercises (paper-based and applications) 2.3 Assessment tools – the selected tools did not align with the learning objectives 2.4 Assessment criteria

Table 5. Phase 3: Development of Instructional Materials and Assessment Tools

Plan	Pre-service teachers created instructional media and assessment tools. After receiving recommendations during Phase 2, they revised and proceeded to develop the instructional media and assessment tools.
Action	Pre-service teachers carried out the creation of instructional media and assessment tools.
Present	1. They submitted their work via Google Classroom and presented it in class. 2. The instructor reviewed the materials and provided feedback.
Reflect	Success in the activity: Pre-service teachers were able to create instructional media that aligned with the content being taught. 1. Pre-service teachers were able to create knowledge sheets using Canva. 2. They developed paper-based exercises. 3. They created digital exercises using Kahoot, Wordwall, google form and Liveworksheets.

Table 6. Phase 4: Permission and Communication

Plan	Permission and Communication: Follow the following order: 1. Pre-service teachers and instructors collaboratively developed a project aimed at solving students' learning problems in school. 2. The instructor prepared official letters to request permission from the school and from parents, as well as a consent form for parental approval of the student's participation in the project (as required by the Faculty of Education). 3. Instructional design documents (initially created in Phase 2 and revised in Phase 3) were prepared to be submitted to the school and parents. 4. A teaching schedule was communicated to the student.
Action	Pre-service teachers carried out the following: 1. The project implementation was proposed and submitted to the Dean of the Faculty of Education. 2. The instructor prepared official letters requesting permission from both the school and the parents. 3. Pre-service teachers delivered the permission letters along with the instructional design documents (from Phase 2, revised in Phase 3) to the school and parents. 4. Pre-service teachers handed the consent forms to the students to bring home for their parents to sign and return, granting permission for participation in the project. 5. The teaching calendar and project details were explained to the students.
Present	The instructor assessed the projects, and pre-service teachers submitted the signed parental consent forms via Google Classroom.
Reflect	1. Some pre-service teachers did not complete the project documents correctly and received feedback from the instructor. 2. There were no issues with delivering the school permission letters. 3. There were delays in submitting parental permission letters and consent forms due to students losing documents or parents not understanding the purpose—additional explanation was required. 4. For students who submitted documents late, the instructor allowed flexibility by extending the submission deadline to support their progress.

Table 7. Phase 5: Implementation of One-on-One Teaching

Plan	Pre-service teachers prepared instructional design documents (initially created in Phase 2 and revised in Phase 3) and their teaching calendars.
Action	Pre-service teachers conducted their lessons according to the teaching calendar and the instructional plans they had designed.
Present	They documented their post-teaching reflections, recorded videos during online sessions, took photographs during learning activities, and collected

	student work submissions (both paper-based exercises and results from learning applications).
Reflect	1. Problem 1: The teaching plan included both online and onsite formats to allow pre-service teachers to practice teaching in both modes. However, in actual implementation, some schools did not have devices such as mobile phones, tablets, or computers available for students, making it impossible to conduct online teaching. Solution 1.1: The instructor made exceptions for cases in which students genuinely had no access to devices or the school had no computers. Solution 1.2: In cases where the school had a computer lab, pre-service teachers were encouraged to simulate an online learning environment by teaching from a tablet in one room while the students participated from the computer lab. 2. Problem 2: Some students did not attend class as scheduled in the teaching calendar. While some informed the pre-service teachers in advance, others were absent without notice. Solution 2.1: Pre-service teachers were advised to be flexible by adjusting the teaching schedule in consultation with the student and coordinating with the mentor teacher. In some cases, makeup sessions were arranged during lunch breaks, homeroom periods, or after school to ensure students received the full learning experience as planned.

Table 8. Phase 6: Final Reporting and Presentation

Plan	The instructor scheduled the presentation sessions and provided a report format for the pre-service teachers.
Action	Roles of the Pre-service Teachers: 1. Submit the final report and PowerPoint presentation two days before the presentation day. 2. resent the outcomes of their student case study, including the problems encountered and how they were addressed. 3. Reflect on what they learned, areas they still need to improve, and how they plan to apply the experience in the future.
Present	The instructor provided feedback, evaluated the written reports, and observed the students' attitudes toward the teaching profession during their reflective presentation, focusing on facial expressions, emotions, and feelings expressed while presenting.
Reflect	The evaluation of the reports and classroom presentations showed the following results: 1. Lesson Planning: Most pre-service teachers were able to write learning objectives correctly. However, 4 students still wrote them incorrectly because they did not revise their work as previously advised.

2. Instructional Delivery: Most students designed diverse instructional activities, often using games and exercises. Some still followed the school textbook directly and only added a game component.

3. Assessment and Evaluation: Students were able to create both multiple-choice and open-ended test items. However, many did not include rubrics for grading open-ended questions or exercises. The instructor advised them to revise this aspect for future teaching sessions.

4. Post-Teaching Reflection: All students submitted reflection logs after teaching. However, the reflections were often brief. This may be because each student taught only one learner, so there were fewer visible challenges. The instructor suggested that reflections include observations in three areas: cognitive, affective, and psychomotor domains of the student.

5. Attitude Toward the Teaching Profession: During interviews conducted at the presentation sessions, many pre-service teachers expressed feelings of happiness and enjoyment from teaching their student. They reported having opportunities to practice speaking, develop their math teaching skills, and tackle unfamiliar math problems brought up by students. They also noted the need for patience, as some students struggled with basic calculations and required multiple explanations. Despite this, they remained determined to help the students succeed.

After completing the case study, some pre-service teachers asked their students whether they were able to do the final exam in mathematics. When students said they could, it gave the pre-service teachers a sense of joy and pride in their students' progress.

Tables 3-8 presents qualitative data collected throughout the data collection. Through the implementation of the intervention across phases 1 to 6, the pre-service teachers demonstrated noticeable improvement in essential instructional competencies. These included lesson planning, instructional delivery, instructional media development and use, as well as assessment and evaluation of student learning. The structured, step-by-step approach allowed participants to engage with each task systematically without feeling overwhelmed. As a result, they reported a more manageable workload and developed a clearer understanding of the teaching process. This gradual and organized learning experience contributed to the development of positive attitudes toward the teaching profession.

5. Discussion

This study's findings indicate that the utilization of Project-Based Learning (PjBL) markedly improved pre-service teachers' individual teaching skills and their perceptions of the teaching profession. Participants demonstrated significant enhancement in all aspects of instructional proficiency, encompassing lesson preparation, instructional delivery, media development, and assessment. The findings correspond with earlier research (Al-Busaidi & Al-Seyabi, 2021; Alrajeh, 2020; DeCoito & Briona, 2023; Molina-Torres, 2022; Rahmawati et al., 2020; Tsybulsky & Muchnik-Rozanov, 2023) which highlighted that project-based experiences facilitate the development of professional identity and practical teaching skills among student teachers. The project's framework promoted active learning and decision-making, enabling pre-service teachers to create lessons customized for individual learners and to immerse themselves in the teaching process.

Furthermore, PjBL enhanced more favorable attitudes toward the teaching profession. The pre-service teachers described sentiments of delight, confidence, and pride while navigating authentic teaching problems. This aligns with McGarr's (2021) findings, which indicated that practical teaching experiences via structured activities can enhance motivation and self-efficacy in pre-service teachers. In this study, it could be observed that the necessity to execute a significant project with genuine student impact enabled the participants to observe concrete outcomes of their endeavors, so strengthening their feeling of purpose and enthusiasm for pursuing careers in education.

In addition, it could be noted that reflective learning significantly contributed to the enhancement of teaching competencies and professional dispositions. During the six phase, participants conducted systematic reflection at each phase of the project. These reflections allowed them to identify strengths, confront issues, and perpetually refine their instructional practices. Participants modified their learning objectives and evaluation strategies following a reflection on discrepancies between their initial designs and the actual classroom execution. This iterative technique enhanced instructional quality and fostered greater professional understanding.

The results align with those of Suphasri and Chinokul (2021), who highlighted that organized reflective practice improves pre-service teachers' abilities in critical thinking and adaptable instruction. McGarr (2021) corroborates this viewpoint, indicating that reflection after practical experiences (such as virtual simulations or teaching projects) enhances instructional reasoning. This study demonstrated a strong correlation between reflective learning and emotional development, with numerous participants recognizing the necessity of patience, empathy, and perseverance for effective individualized training. The emotional responses articulated throughout the concluding thoughts and presentations underscored an enhanced professional identity and bolstered favorable sentiments about the teaching profession.

6. Conclusion

This study sought to enhance the one-on-one instructional skills and professional dispositions of pre-service mathematics teachers through the integration of Project-Based Learning (PjBL) and Reflective Learning. The study employed an embedded mixed-methods approach, utilizing six phase, during which participants developed and executed personalized instructional projects for actual students. The results demonstrated considerable development in both pedagogical abilities and perceptions of the teaching profession. This study enhances teacher education research by filling gaps left by previous investigation, which frequently emphasizes PjBL for general classroom instruction instead than personalized teaching. It illustrates that the incorporation of Reflective Learning into Project-Based Learning not only improves teaching efficacy but also fosters favorable views about the profession.

The study's implications indicate that teacher education programs have to integrate structured, project-based experiences featuring reflective elements, especially those that replicate authentic teaching situations. Engaging in this practice can cultivate essential pedagogical abilities, enhance self-awareness, and reinforce professional identity in prospective educators.

7. Recommendations

Nonetheless, the study possesses specific limitations. The sample size was comparatively small and confined to a single cohort of pre-service mathematics educators, potentially impacting the generalizability of the results. The study was devoid of a control group, precluding the assessment of comparative results with alternative instructional methodologies. Future studies should undertake analogous interventions, with control groups or multiple groups, and encompass additional topic areas and educational levels. Comparative research utilizing control groups could yield more insights into the efficacy of Project-Based Learning (PjBL) and Reflective Learning in contrast to conventional

techniques. Longitudinal studies might investigate whether the competencies and dispositions cultivated by this methodology are maintained as pre-service teachers transition into permanent teaching positions.

Declarations

Author Contributions. Apantee Poonputta: Literature review, conceptualization, data collection, Methodology, data analysis, and manuscript preparation. Wanicha Sakorn: Conceptualization, review, editing, and report. All authors have read and approved the final version of the article for publication.

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Ethical Approval. This study was conducted in compliance with ethical standards and was approved by the Mahasarakham University, under approval number 769-744/2567. All participants provided informed consent prior to participation, and their privacy and confidentiality were protected throughout the study.

Data Availability Statement. The data supporting the results reported in this study are available from the corresponding author upon reasonable request.

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