Al-Ishlah: Jurnal Pendidikan
Vol.17, 1 (March, 2025), pp. 1618-1631
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v17i1.5876

The Pedagogical and Professional Abilities of Pre-Service Teachers through a Project-Based Research Learning Model

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ARTICLE INFO

Keywords:

Project-Based Research Learning;
Pedagogical;
Professional Ability;
Pre-service teacher

Article history:

Received 2024-08-17
Revised 2024-11-28
Accepted 2025-03-28

ABSTRACT

The *Kurikulum Merdeka* (Independent Curriculum) policy allows pre-service teachers to engage in two-semester internships, offering extended practical experience in schools. This study aimed to analyze the pedagogical and professional abilities of pre-service teachers in the digital era following the implementation of the Project-Based Research Learning model within the Teaching Assistance program. A mixed-methods approach was employed, combining quantitative and qualitative data. Research instruments included open-ended questionnaires and in-depth interviews. Data were analyzed using descriptive statistical techniques and thematic qualitative analysis. Findings revealed that pre-service teachers demonstrated strong pedagogical and professional competencies in the digital teaching environment after applying the Project-Based Research Learning model. Most participants favored group projects over individual assignments, citing benefits such as: fostering collaboration aligned with *gotong royong* (mutual cooperation) values, facilitating shared problem-solving, expediting project completion, and reducing individual workload. The study also identified several challenges faced by pre-service teachers during implementation, including classroom management and digital content adaptation, which are discussed in detail. The Project-Based Research Learning model effectively enhances both pedagogical and professional competencies among pre-service teachers in the digital era. Group-based projects are particularly beneficial for collaborative skill development. Future research should further explore strategies to address the challenges encountered during digital teaching practice.

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1. INTRODUCTION

Indonesia is currently implementing the *Kurikulum Merdeka* (Independent Curriculum), a transformative educational policy that emphasizes student-centred learning and the integration of project-based approaches in both teaching and teacher training (Kazun & Pastukhova, 2018a). One key component of this curriculum is the Teaching Assistance Program, which provides pre-service teachers with the opportunity to engage in real-world teaching experiences through direct involvement in schools.

Teaching Assistance is a life-based learning model that allows students to apply theoretical knowledge to authentic classroom settings, fostering deeper understanding and skill development (Anggraeni et al., 2022; Sviridova, 2023). It enables pre-service teachers to conduct classroom-based research, explore project-related themes, exercise critical judgment, and collaboratively solve real problems encountered in school environments (Brandt et al., 2021; Leonova et al., 2022). This model also supports students in understanding social, scientific, and educational issues, particularly when applied within elementary and junior high school contexts (Sumarmi, 2012). To enhance the quality of learning and research outcomes, it is essential to incorporate innovative learning models such as Project-Based Research Learning (PBRL) during Teaching Assistance (Sumarmi et al., 2021).

Pre-service teachers involved in Teaching Assistance are tasked with four core responsibilities: (a) teaching literacy, (b) teaching numeracy, (c) supporting technology integration, and (d) assisting with administrative duties. These tasks are designed not only to improve academic and pedagogical competence but also to develop essential soft skills—including leadership, teamwork, empathy, and creativity—which are critical attributes for future educators (Santos & Castro, 2021). These responsibilities align with the program's slogan, "Mengabdi untuk Negeri" (Serving the Nation), as the program fosters contributions to education at the primary and lower-secondary levels (Santoso et al., 2022).

The Teaching Assistance Program is structured into three main stages. The Preparation Stage involves observing the school environment and compiling an initial report in collaboration with the university team during the first week of placement. In the Implementation Stage, which spans 20 weeks, students engage in teaching, submit daily logbooks and weekly reports, maintain communication with field supervisors (Dosen Pembimbing Lapangan), and participate in biweekly curriculum sharing sessions. The final Analysis Stage includes the preparation of a final report summarizing student activities and outcomes, with evaluations conducted by supervisors, peers, and in-school mentors (Anwar, 2021). During this period, students are also required to implement the Project-Based Research Learning (PBRL) model.

Project implementation in schools follows three stages. In the initial stage, project themes are applied uniformly across all classes. In the development stage, themes are applied consistently across 2–3 classes. Finally, in the advanced stage, each class determines its own project schedule, offering greater flexibility and autonomy (Wahyuni & Riyanto, 2022). These varying conditions directly impact the pedagogical and professional competencies of pre-service teachers, particularly as they navigate the demands of teaching in the digital era.

Various teaching assistance programs have been implemented, including Kindergarten teaching assistance programs (Restiningtyas et al., 2022; Taufiqurrahman et al., 2022). Teaching assistance in elementary schools (Anwar, 2021; Hikmah et al., 2022; Santoso et al., 2022). Teaching assistance in junior high schools (Muthi'ah et al., 2021; Stefanus et al., 2022; Wahyuni & Riyanto, 2022). Teaching assistance in Senior High School in Malang city (Anggraeni et al., 2022; Saputra & Julianti Kasih, 2022). Meanwhile, in many other countries, teaching assistance is referred to as pre-service teacher.

Preparing pre-service teacher students to become sustainable teachers has been studied by students at Arizona State University (Brandt et al., 2021). Research continues to be conducted on pre-service teacher students at Bulacan State University, it was found that pre service teacher students have good knowledge of TPACK (Santos & Castro, 2021). In Belgium, a survey of 20 Teacher Training Institutions revealed a good correlation between the use of the SQD technique and the TPACK

competencies of pre-service teachers (Tondeur et al., 2020). In the German federal state of North Rhine-Westphalia, pre-service teacher profiles are categorized as profiles with knowledge and experience, profiles with lack of experience, and profiles with no experience (Holzberger et al., 2021).

In addition, research on pre service teachers at the University of Applied Sciences Netherlands indicated a positive correlation between the pre service teacher's capacity to develop research and their teaching abilities (Van Katwijk et al., 2021). An experimental study was conducted on pre-service teachers in Germany, and the results showed that using the TPACK module improved pre-service teachers' teaching abilities (Lachner et al., 2021). In a study conducted at the school of scientific education in China, it was revealed that pre-service teachers who used flipped classrooms had higher levels of learning achievement, learning satisfaction, learning motivation, and self-efficacy (Zhao et al., 2021). However, no research has been conducted regarding the use of the PBRL model to pre-service teachers. Therefore, the PBRL model must be used to improve the teaching abilities of pre-service teachers by applying for Teaching Assistance.

The implementation of project-based learning (PBL) varies across countries - the United States emphasizes social and technological competencies, Finland focuses on student autonomy in projects, France prioritizes industrial needs, Australia concentrates on professional development, and China emphasizes socio-environmental initiatives (Kazun & Pastukhova, 2018). Case studies at universities such as the Technical University of Iaşi Romania have been documented (Panaite et al., 2014). In Slovakia, PBL has been implemented in mechanical and electrical engineering fields, driven by faculty initiative (Tináková et al., 2011). These various studies demonstrate that the integration of PBL with research-based learning has enhanced student learning outcomes and professional skills. Although challenges exist in PBL design and implementation, its combination with e-learning and the provision of detailed resources can support effective implementation.

The Teaching Assistance Program emphasizes that learning through direct experience is more effective in helping students achieve learning goals. This model offers multiple benefits, including increasing student motivation, supporting goal attainment, providing self-satisfaction, benefiting both students and schools, promoting relevant and meaningful learning, and creating a balance between learning and working. It also helps bridge the gap between the curriculum and real-world classroom situations (Dichabeng & Moalosi, 2016). When designed in a contextual and school-specific manner, Teaching Assistance becomes even more meaningful by applying service-learning concepts (Krebs, 2008).

Universities can design different types of Teaching Assistance activities based on the needs and characteristics of each study program. These activities can be integrated into course credits, allowing students to meet graduation requirements in various ways. For example, students may complete all 146 credits within their own program or combine 106–126 credits in their major with additional credits through interdisciplinary courses, other institutions, or off-campus experiences. The Independent Curriculum policy supports this flexibility by converting up to 20 credits into Teaching Assistance activities for education students, coordinated by the Education and Learning Development Institute (LP3). For non-education students, a similar program called Village Development is managed by the Institute for Research and Community Service (LP2M).

In addition to teaching, pre-service teachers are required to conduct research that contributes to their thesis articles. This research is often aligned with themes from the Independent Curriculum, such as global climate change, local wisdom, unity in diversity, physical and mental wellness, democracy, science and technology for national development, and entrepreneurship (Santoso et al., 2022). These themes are used as the foundation for project-based learning in schools where Teaching Assistance is conducted.

The Independent Project-Based Research Learning (PBRL) model is central to this program. Unlike traditional projects based solely on literature, PBRL emphasizes that students must first conduct real, contextual research before developing a project. These research activities are grounded in the actual problems students encounter during their teaching placements. This approach connects theory with

practice and allows students to develop pedagogical depth through active learning, creativity, feedback, collaboration, and guided discussions with mentors and teachers. Teaching Assistance becomes a space where theories, concepts, and practical experiences are critically analyzed and applied. It also promotes meaningful relationships between university students and the schools they serve.

According to Kaye (2010), the Independent Project-Based Research Learning model consists of four main stages. In the preparation stage, students investigate and assess school-based problems through observation, interviews, and information gathering. During the action stage, they implement their project plans and propose solutions to the identified issues. The reflection stage involves evaluating outcomes, identifying challenges, and documenting their experiences in a thesis article. Finally, in the demonstration stage, students report their results to lecturers, school partners, and through academic publications.

The implementation of project-based learning in schools varies depending on their level of readiness. In the initial stage, schools may have limited experience and understanding of project-based learning, with minimal external involvement. In the developing stage, teachers become more familiar with the approach and begin involving external partners. At the advanced stage, project-based learning is embedded in the school's culture, all teachers understand the methodology, and partnerships with outside organizations are established to ensure the sustainability and broader impact of projects (Stefanus et al., 2022).

Building on the discussion above, this study aims to explore the impact of the Project-Based Research Learning model within the Teaching Assistance Program on the development of pre-service teachers in the digital era. Specifically, the research focuses on analyzing both the pedagogical and professional competencies of pre-service teachers after participating in this model. By examining these two core aspects, the study seeks to understand how experiential, research-driven teaching practice contributes to preparing future educators for the evolving demands of 21st-century education.

2. METHODS

2.1 Research Analysis

This study used quantitative data to conduct analysis. Quantitative data is required to determine the effectiveness of the data obtained. Data was collected by distributing questionnaires to pre-service teacher students and observing their responses after participating in teaching aid activities. The questionnaire is determined by calculating the total score (Sugiyono, 2014) using the following formula:

$$N = \frac{K}{Nk} \text{ X } 100\%$$

Description:

N = Ability Percentage Persentase kemampuan

K = Score for obtained data

Nk = Total maximum score

The obtained results are then compared to the intervals in Table 1 as follows:

Table 1. Interval Criteria

Percentage Interval N	Conversion
85% < N ≤ 100%	Very high
72% < N ≤ 85%	High
58% < N ≤ 72%	Moderate
4% < N ≤ 58%	Low
N ≤ 44%	Very Low

(Source: Research analysis, 2022)

2.2 Participants

This researcher selected mentor teachers for Geography students conducting teaching assistance programs in Malang City, Geography teachers at SMAN 2 Pare Kediri, Geography teachers at SMAN I Kediri, and Geography teachers at SMPN 5 Trenggalek. In total, the teaching assistance program was implemented across 17 schools. There were 32 supervising lecturers, 26 mentor teachers, and 87 students participating in the Teaching Assistance program. In addition to supervision from supervising lecturers and mentor teachers, environmental volunteers from the Bhakti Alam Foundation in Sendangbiru Malang provided support, particularly in assisting with project implementation related to mangrove conservation. This study involved presenting questionnaires to supervising lecturers, mentor teachers, and participants of the teaching assistance program, as well as conducting Focus Group Discussions (FGDs) with school principals and vice principals.

2.3 Research Instrument

The research design used a mixed method, a combination of quantitative and qualitative methods (Johnson & Christensen, 2013). The research instrument included an open-ended questionnaire and interviews. Questionnaires were distributed to teachers and supervisors at schools where pre-service teacher students participated in Teaching Assistance programs. The data were analyzed using descriptive quantitative and descriptive qualitative approaches. The questionnaire instrument is shown in table 2.

Table 2. Research Instrument

No	Pedagogical Ability	Professional Ability
a	Capable of mastering the characteristics of students	Capable of mastering the material or learning materials
b	Capable of mastering learning theory and learning principles to educate students	Capable of designing various educational administrations (lesson plans, syllabus, teaching materials, learning assessment)
c	Capable of developing a curriculum	Capable of transferring knowledge to students effectively
d	Capable of conducting learning activities to educate students	Continue to learn and develop the skills and abilities with high motivation
e	Capable of developing students' potential	Capable to develop active, creative, and innovative learning
f	Capable to communicate with students	Capable of updating information or issues that occur around, especially education issues
g	Capable to conduct learning assessment and evaluation	Master good digital skills such as operating a computer or other educational support technology

(Source: Research analysis, 2022)

The research instrument was then distributed to school teachers and field supervisors (DPL) to be completed based on their observations of pre-service teachers while implementing the Teaching Assistance program. School teachers and supervisors submit evaluations based on the questionnaire's questions. Furthermore, the data is analysed based on research questions. The data were collected and then examined quantitatively to determine the average score for pedagogical and professional qualities. The quantitative results were then analyzed qualitatively to provide a more complete explanation of the research findings.

3. FINDINGS AND DISCUSSION

This study aimed to determine the ability of pre-service teachers from a pedagogical and professional perspective. The following are the research results and discussion.

3.1 Pedagogical Ability of Pre-service Teacher

The result showed that pre-service teacher students had good pedagogical skills in the digital era after using the Project Based Research Learning model in the Teaching Assistance program. The pedagogical abilities of pre-service teacher students are shown in the following Figure 1.

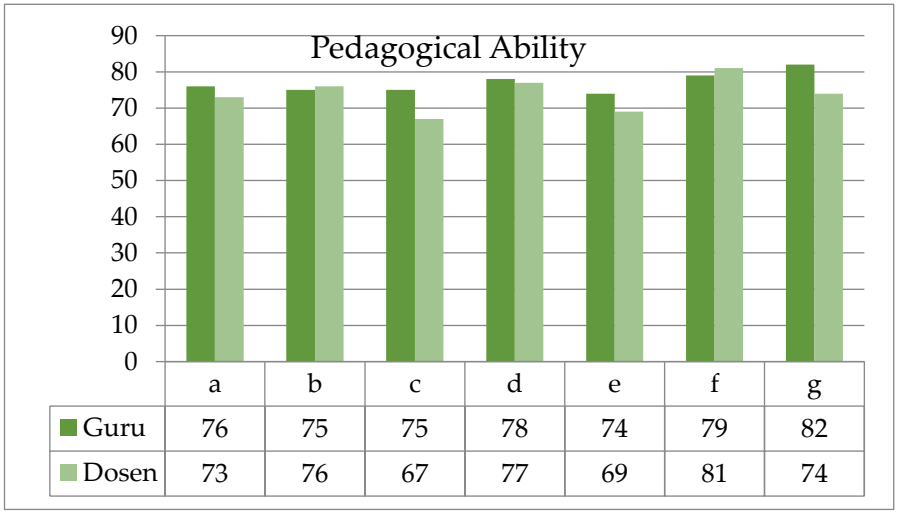


Figure 1. Pedagogical Ability of Pre-service Teacher
(Source: Research analysis, 2022)

Figure 1 shows that the pedagogical abilities of pre-service teacher students are in good results. The pedagogical ability of pre-service teachers is supported by a number of indicators evaluated by teachers and supervisors, as discussed in detail below.

Pre-service teachers receive a score of 76 from school teacher and 73 from supervisor. Pre-service teachers are skilled at understanding the qualities of their students. This is a critical skill that pre-service teachers must acquire since, by understanding the characteristics of students, they can adapt learning activities to students' capacities (Goldman & Grimbeek, 2015). Indonesia has just implemented a new curriculum known as the *Kurikulum Merdeka* (Independent Curriculum). This program is flexible enough to accommodate all student characteristics. Students can learn based on their abilities and preferred learning strategies. Therefore, in order to manage this curriculum, pre-service teachers must be able to identify student characteristics effectively. Pre-service teachers must be able to engage students in learning, develop their interests and emotions in line with each student's capacities (Brandt et al., 2021).

According to the questionnaire results, the ability of pre-service teacher students received a score of 75 from the school teacher and a score of 76 from the supervisor. This indicator indicated that pre-service teachers must be able to master learning theory and principles. Pre-service teacher students can create learning based on theories that have been shown to be effective when they are familiar with the learning theories and principles. The implementation of these learning theories and principles can maximize student learning activities to achieve learning outcomes (Pepin et al., 2019).

The pre-service teacher receives 75 from the school teacher and 67 from the supervisor on the curriculum development indicator. Based on this score, the pre-service teacher can improve the ability to develop learning tools through courses on campus. Pre-service teachers must also be able to create learning media. This skill is required to design and develop learning materials that are contextual and relevant with the learning environment students experience. Contextual learning will be easily comprehended by students because it allows them to gain direct learning experience (Veletsianos et al., 2015).

Furthermore, the pre-service teacher received a score of 78 from the school teacher and 77 from the supervisor for indicators of capability to conduct educational learning activities. Currently, classroom learning must be capable of preparing students to face global problems and competition.

However, learning must also prepare students to develop positive character. Therefore, pre-service teachers must be able to provide students with activities that will help them become good students with strong character who can compete globally (Goldman & Grimbeek, 2015; Rokhman et al., 2014).

The next indicator received 74 points from the school teacher and 69 points from the supervisor. This assessment examines the ability of pre-service teachers to develop the potential of their students. According to the supervisor, the pre-service teacher has a good ability. Therefore, pre-service teachers must improve their abilities to develop student potential. Pre-service teachers must be prepared to improve their potential by adjusting their learning style to students' abilities (Holzberger et al., 2021).

The next indicator is that the pre-service teacher is able to communicate well with students. The teacher gave a score of 79, but the supervisor gave a score of 81. Therefore, this ability in communication receives a good category. The teacher must use language that is easily comprehended by students in order to effectively deliver the subject. Teachers must interpret abstract concepts into concrete lessons so that students can understand it (Schmid et al., 2021).

A pre-service educator must be able to assess student abilities in order to perform assessments. Based on the results of the assessment in this study, the teacher gave a score of 82 and the supervisor gave a score of 74. Pre-service teachers must be able to design and create instruments for evaluating student learning. The learning assessment could evaluate students' cognitive, affective, and psychomotor abilities (Van Katwijk et al., 2021). This ability assessment is essential for determining the level to which students understand after receiving instruction from the teacher. In addition to pedagogical skills, pre-service teachers must be able to connect learning factors, including personal, professional, structural, and social connections (Brandt et al., 2021).

The difference in outcomes between school teachers and supervising lecturers can be attributed to differing assessment perspectives and contexts. School teachers evaluate based on direct observation of student teachers' performance in daily classroom situations, while supervising lecturers assess from a more rigorous academic and theoretical standpoint. This is particularly evident in several indicators, such as curriculum development (teachers: 75, supervisors: 67) and student assessment capability (teachers: 82, supervisors: 74), where lecturers tend to assign lower scores due to higher expectations regarding the application of theory and academic standards in teaching practice.

3.2 Professional Ability of Pre-service Teacher

After using the Project Based Research Learning model in Teaching Assistance program, the result showed that pre-service teacher students had good professional skills in the digital era. The pedagogical abilities of pre-service teacher students are shown in the following Figure 2.

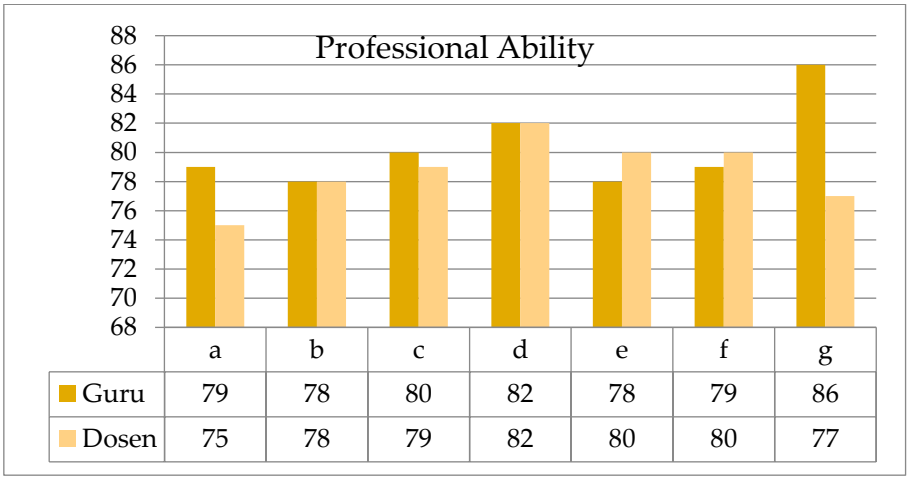


Figure 2. Professional Ability of Pre-service Teacher
(Source: Research analysis, 2022)

Based on the data presented in Figure 2, pre-service teachers demonstrated strong mastery of learning materials, earning a score of 79 from school teachers and 75 from supervisors. Mastery of subject matter is considered one of the most essential teaching competencies, as it directly impacts the ability to transfer knowledge effectively to students (Lachner et al., 2021; Schmid et al., 2021). In the context of 21st-century education, this skill aligns with the TPACK framework, particularly the need for solid content knowledge. A study conducted among 173 pre-service teachers at a Swiss university also highlighted content knowledge as a dominant factor in teaching effectiveness (Schmid et al., 2021).

In addition, pre-service teachers demonstrated a good ability to develop learning tools, with both school teachers and supervisors assigning a score of 78. Designing effective learning tools requires the integration of content, pedagogy, and technology—key elements of TPACK (Tondeur et al., 2020). However, previous research with Dutch primary school students revealed that despite the integration of TPACK-based tools, their practical application still received relatively low evaluations (Janssen et al., 2019). This suggests that pre-service teachers must continue to strengthen their ability to meaningfully integrate technology into lesson planning.

Another key indicator assessed was the ability to transfer knowledge to students, which received scores of 80 from school teachers and 79 from supervisors. This ability is crucial for helping students understand subject matter within real-life and contextual frameworks. When teachers present material in ways that students find relevant and applicable, learning outcomes tend to improve (Van Katwijk et al., 2021).

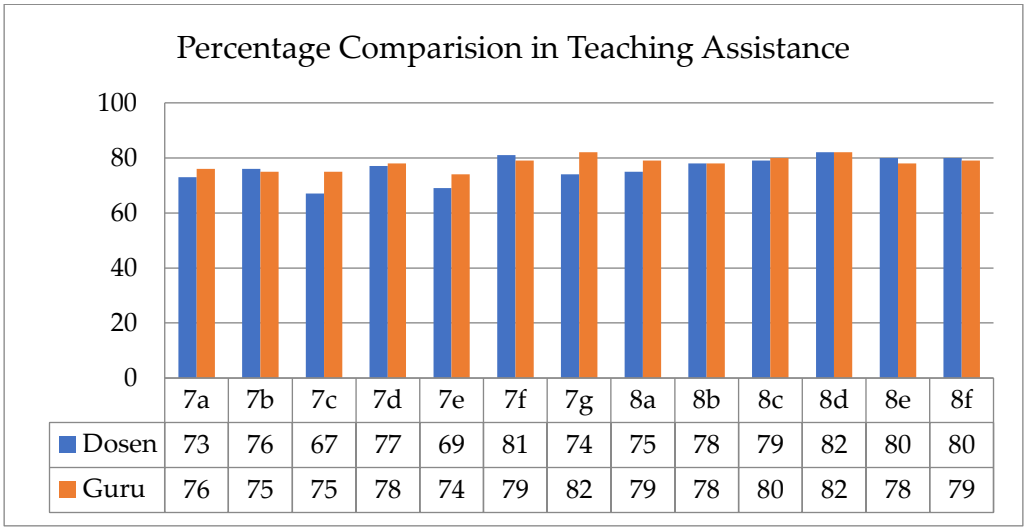
Motivating students is also essential in improving learning quality. On this indicator, both the school teacher and the supervisor gave pre-service teachers a score of 82. Motivation, when combined with student efficacy, has a strong impact on learning satisfaction, cognitive engagement, and emotional stability (Zhao et al., 2021). Learning experiences that foster student confidence and emotional regulation ultimately support better academic performance.

Pre-service teachers also showed good performance in developing learning environments that are active, creative, and innovative. The school teacher assigned a score of 78, while the supervisor gave a slightly higher score of 80. Encouraging creativity through the use of digital tools and information resources has been shown to enhance inquiry-based learning and independent thinking (Santos & Castro, 2021; Van Katwijk et al., 2021). As future educators, pre-service teachers must be equipped to design and lead learning experiences that are student-centered, research-driven, and technology-enhanced (Golightly, 2022).

Lastly, the ability to stay updated with current issues in education was rated positively, with a score of 79 from the teacher and 80 from the supervisor. This skill is closely tied to digital literacy, particularly the ability to access, evaluate, and utilize various sources of information. Pre-service teachers demonstrated proficiency in using technology tools and platforms to gather relevant content, which is crucial in today's information-rich educational landscape (Golightly, 2022). The ability to operate computers and stay informed are closely linked, as noted by Janssen et al. (2019), and their integration is key to improving the overall quality of teaching and learning.

3.3 Comparative Description from Supervisors in the Teaching Assistance Program

Based on a comparison of supervisor and school teacher, a further descriptive analysis evaluation is shown in the following Figure 3.



	7a	7b	7c	7d	7e	7f	7g	8a	8b	8c	8d	8e	8f
Dosen	73	76	67	77	69	81	74	75	78	79	82	80	80
Guru	76	75	75	78	74	79	82	79	78	80	82	78	79

Figure 3. Comparison of Evaluation from School Teachers and Supervisors

Figure 3 presents a comparison of the pedagogical and professional abilities of pre-service teachers based on assessments from both school teachers and university supervisors. While most evaluations fall within the "good" category, notable differences appear in the responses to questions 7c and 7e. For question 7c, which assesses the ability to develop curriculum, school teachers rated this competence as "good," while supervisors rated it as "moderate." Conversely, for question 7e, which focuses on the ability to develop students' potential, teachers placed it in the "good" category, while supervisors assessed it more positively, placing it in the "very good" category.

The differing results in question 7c highlight an important area for reflection. The teacher's score of 67 suggests that pre-service teachers may face challenges in curriculum development, falling into the moderate category. This may be due to limited exposure to curriculum design processes during their academic preparation. Ideally, pre-service teachers should be well-prepared to understand curriculum structure and effectively adapt it to real classroom needs (Janssen et al., 2019; Pepin et al., 2019). The findings suggest a gap between theoretical knowledge and practical application, indicating the need for more hands-on training in curriculum planning.

In contrast, the differing perspectives on question 7e suggest a more nuanced understanding of how pre-service teachers support student development. While supervisors rated this ability as "very good," teachers rated it slightly lower, though still within the "good" category. One explanation may be that supervisors evaluate from a more theoretical or macro perspective, while teachers observe direct interactions and may be more critical of how effectively pre-service teachers engage students. This difference may also stem from the limited teaching experience of pre-service teachers, particularly in recognizing and nurturing individual student potential. Such limitations are often influenced by age differences, classroom management challenges, and a developing understanding of child psychology (Holzberger et al., 2021; Goldman & Grimbeek, 2015).

Overall, both teachers and supervisors generally view the professional abilities of pre-service teachers as good, with only a few areas requiring further improvement. These results suggest that pre-service teachers are making meaningful progress, but that targeted support is still needed in certain pedagogical domains. To address these gaps, coursework related to pedagogy should be reinforced with practical training, particularly in curriculum development and strategies for identifying and supporting students' individual needs. Such preparation is essential to ensure that pre-service teachers are equipped to transition smoothly into professional teaching roles.

3.4 PBRL: individual or group project

Only 2 of the 32 responders chose individual projects, while the remaining 30 chose group projects. Group projects provide advantages such as 1) emphasizing the collaborative aspect based on gotong royong (cooperation) values, 2) sharing and finding solutions to difficulties experienced at school, 3) requiring a team to speed up project completion, and 4) work feels easier. Based on the result analysis, it can be concluded that pre-service teachers are already familiar with the benefits and objectives of implementing projects in groups. Cooperation is essential for students to face real-world situations when they become teachers (Kaye, 2010). Teachers that can collaborate with leaders and other teachers are competent and capable of adjusting to different developments (Rokhman et al., 2014). Competent teachers may share their information effectively and are liked by their students (Zhao et al., 2021).

The two respondents who decided to complete the project individually did so for the following reasons: (1) they wanted to learn more about the cognitive abilities of each student; (2) to finish optimally and because it is still a pandemic; (3) to finish optimally given that it is still a pandemic; (4) they lacked the initiative to create a project. At times, a teacher must also be familiar with the methods and strategies used by students with auditory, visual, spatial, or kinesthetic learning styles (Anggraeni et al., 2022). There are some students with intrapersonal intelligence along with interpersonal intelligence. Pre-service teachers understand the conditions of variations in classes as service to students (Dichabeng & Moalosi, 2016). Furthermore, pre-service teachers who independently complete this project are treated in the same manner. Some of these explanations demonstrate that intrapersonal intelligence contributes to the growth of human cognitive abilities (Sadiku & Musa, 2021).

3.5 The reason for the learning design is not suitable

The design created by the pre-service teacher was considered suitable by 24 of the 32 respondents, while it was considered unsuitable by 8 respondents for the following reasons: (1) time constraints; (2) because projects lead to non-academic activities, academic activities follow supervisors' instructions; (3) the teacher has not given the project as intended, and the pre-service teacher is not used to to working on projects; (4) based on teacher information, pre-service teachers continue to use conventional methods of teaching. This is possibly due to lack of planning and leadership; (5) the project requires funding, but there is no allocation for project activities, and school facilities, such as a social laboratory, are not yet funded. The readiness of school stakeholders who have not been identified for the use of project findings; (6) the implementation of learning is restricted by limitations. Pre-service teacher has not taken several pedagogical courses, resulting in a lack of mastery of fundamental learning abilities; (7) due to time restrictions, project learning is conducted offline and online, resulting in inefficient use of time.

3.6 Problems found in implementing project-based learning

The introduction of project-based learning for students in the Teaching Assistance program faces various challenges. The pre-service teacher described the limitations and difficulties they faced while implementing the Teaching Assistance program. Following are some of the challenges experienced:

1. Time management and the quantity of additional work assigned by the school to Teaching Assistance program students outside of the project are the most common obstacles.
2. During the implementation of the Teaching Assistance program, schools continue to use blended learning; therefore, the pre-service teacher must develop learning to ensure the success of the project.
3. They are not used to collaborating and collecting data in the field. This learning requires more time than typical learning. Monitoring student performance, particularly the fundamental learning processes, is time-consuming.

4. The concept of project-based learning is not yet fully understood. In addition to being passive, students lack the initiative to ask questions and engage in in-depth conversations.
5. All of the pre-service teacher's projects are currently in the planning stage.
6. Due to economic limits and a lack of school facilities, it was impossible to implement the project (several groups of pre-service teachers were guided to design an online library and pilot social laboratory).
7. Online learning is more popular than offline learning, making coordination challenging.
8. The Teaching Assistance Program has been tasked with instructing 10th grade geography topics utilizing the prototype curriculum or an independent curriculum. Developing learning objectives, learning tools, and specific curriculum modules was a challenge for the pre-service teacher. Even though the old curriculum was used as a learning resource for the first five semesters of pre-service teacher education, the old curriculum was still used as a resource.
9. Lack of specificity in comprehending the condition of the students
10. Lack a complete comprehension of the circumstances of students
11. The various personalities of pre-service teachers and the pandemic's support make them free and even lazy.
12. Pre-service teachers must meet for longer periods of time in order to complete an assignment
13. Lack of mentorship time on the part of school teachers
14. Reduced capacity to monitor pre-service teachers conducting research outside of school

Typically, the lack of experience of students is responsible for a number of the problems mentioned above. The acquired knowledge is still of a theoretical nature, which is significantly different from field experience. Therefore, students are generally surprised to discover the realities of the field. Therefore, the campus must provide sufficient information regarding the school situation.

3.7 Implementation of PBRL and Application of Digital Technology in Supporting Pre-service Teacher Competencies

Implementing Project-Based Research Learning (PBRL) in the teaching assistance program has positively impacted pre-service teachers' pedagogical capabilities, particularly in understanding student characteristics and applying effective learning theories. PBRL encourages pre-service teachers to conduct research before creating learning projects, resulting in more contextual and meaningful learning experiences for students (Veletsianos et al., 2015). This capability is crucial considering the implementation of the Merdeka Curriculum, which requires flexibility in accommodating diverse student characteristics (Brandt et al., 2021). Through PBRL, pre-service teachers can also develop skills in designing comprehensive learning assessments that encompass cognitive, affective, and psychomotor aspects (Van Katwijk et al., 2021).

The integration of digital technology in PBRL supports the development of pre-service teachers' professional capabilities in the digital era. Pre-service teachers demonstrate strong competencies in mastering learning materials and developing technology-based learning tools (Tondeur et al., 2020). This capability is evidenced by high scores in learning technology mastery indicators, where school teachers assigned a score of 86 and supervisors assigned a score of 77. Technology utilization also assists pre-service teachers in accessing current information and developing active, creative, and innovative learning experiences (Santos & Castro, 2021). This aligns with research by (Lachner et al., 2021), which indicates that mastery of content and technology are crucial factors in knowledge transfer to students.

4. CONCLUSION

This study concludes that the implementation of the Project-Based Research Learning (PBRL) model within the Teaching Assistance program effectively enhances the pedagogical and professional competencies of pre-service teachers in the digital era. The findings indicate that pre-service teachers are well-prepared to navigate modern educational challenges, with a notable preference for

collaborative group work over individual projects. Group-based learning was found to foster values of gotong royong (mutual cooperation), encourage shared problem-solving, improve project efficiency, and make tasks feel more manageable. However, the study also acknowledges a limitation: it did not explore in depth the outcomes of independent project work, which may offer additional benefits such as enhancing students' ability to recognize and respond to diverse learner needs, particularly through the lens of multiple intelligences. Future research is recommended to examine the impact of individual learning approaches within the PBRL framework, as well as to explore how such models can be adapted to support a broader range of learning styles and student characteristics. Investigating these aspects would provide a more comprehensive understanding of how PBRL can be optimized to support both collaborative and independent skill development among future educators.

Acknowledgments: The research was supported by the communities, informants, research institutions, community service division and the Department of Social Science, Universitas Negeri Malang.

Conflicts of Interest: This research has received legality from campus institutions so that there is no conflict of interest for individuals, community groups and other institutions.

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