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MATHEMATICS LEARNING IN THE DIFUSI ERA: STRATEGIES AND CHALLENGES IN MADRASAH IBTIDAIYAH

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Abstract

This study aims to examine the effectiveness of the application of Project-Based Learning strategies combined with digital classroom media in learning basic mathematics for prospective elementary school teachers. The background of this research is based on students' low interest and understanding of mathematics, as well as the dominance of conventional learning approaches that are still teacher-centered. Through the *Project-Based Learning* approach, students are involved in making project-based learning media according to math materials such as KPK, FPB, whole numbers, fractions, and flat shapes. This process is also strengthened by the use of digital media for discussion, collaboration, and online task collection. The research used a quantitative descriptive approach with data collection techniques in the form of questionnaires distributed to 24 students. The results showed that 58.3% really understood the material taught, and 79.1% considered the learning strategy used to be effective. In conclusion, the digital classroom-based *Project-Based Learning* strategy is able to increase students' involvement, understanding, and motivation to learn mathematics. This approach also trains 21st century skills such as collaboration, creativity, and communication, and prepares students as competent teachers in the digital era.

Keywords: Project-Based Learning, Digital Classroom, Mathematics Learning, Prospective Teacher Students, Learning Strategy

Abstrak

Penelitian ini bertujuan untuk menguji efektivitas penerapan strategi Pembelajaran Berbasis Proyek yang dikombinasikan dengan media kelas digital dalam pembelajaran matematika dasar bagi calon guru sekolah dasar. Latar belakang penelitian ini didasarkan pada rendahnya minat dan pemahaman siswa terhadap matematika, serta dominasi pendekatan pembelajaran konvensional yang masih berpusat pada guru. Melalui pendekatan Pembelajaran Berbasis Proyek, siswa dilibatkan dalam pembuatan media pembelajaran berbasis proyek sesuai dengan materi matematika seperti KPK, FPB, bilangan bulat, pecahan, dan bangun datar. Proses ini juga diperkuat dengan penggunaan media digital untuk diskusi, kolaborasi, dan pengumpulan tugas daring. Penelitian ini menggunakan pendekatan deskriptif kuantitatif dengan teknik pengumpulan data berupa kuesioner yang dibagikan kepada 24 siswa. Hasil penelitian menunjukkan bahwa 58,3% benar-benar memahami materi yang diajarkan, dan 79,1% menganggap strategi pembelajaran yang digunakan efektif. Kesimpulannya, strategi Pembelajaran Berbasis Proyek berbasis kelas digital mampu meningkatkan keterlibatan, pemahaman, dan motivasi siswa dalam belajar matematika. Pendekatan ini juga melatih keterampilan abad ke-21 seperti kolaborasi, kreativitas, dan komunikasi, serta mempersiapkan siswa sebagai guru yang kompeten di era digital.

Kata kunci: Pembelajaran Berbasis Proyek, Kelas Digital, Pembelajaran Matematika, Calon Guru, Strategi Pembelajaran

INTRODUCTION

Learning mathematics in elementary school has a very important role in forming the basis of logical, analytical, critical and systematic thinking skills for students. Mathematics is not only a stand-alone subject, but also a foundation for understanding other concepts in science and technology. The ability to count, understand patterns, think coherently, and solve problems are essential skills that need to be honed early on through learning mathematics. However, the process of teaching and learning mathematics at the primary school level often faces various challenges that can hinder the achievement of these educational goals (Wulansari, 2021).

One of the problems that is often encountered is the low interest and motivation of students in learning mathematics. Many students feel that math is a difficult, abstract subject that is irrelevant to everyday life. They tend to learn mechanically, memorizing formulas and doing problems without really understanding the concepts behind them (Harefa, 2023). As a result, learning becomes monotonous and less fun, which ultimately has an impact on students' low learning outcomes. Teacher-centered learning models still dominate the classroom, with a one-way approach that lacks interaction and active involvement from students (Mitrayana, 2023). Mathematics learning problems occur not only at the student level, but also in the education process of prospective teachers. Students of basic education study programs who are prepared to become primary school teachers often have negative perceptions of mathematics due to unpleasant learning experiences in the past (Kusuma, 2020). Many of them consider math to be a difficult subject to master, so they do not feel confident to teach it later in the classroom. When prospective teachers have a weak understanding of concepts, lack creativity in delivering material, and do not master adaptive and contextual learning strategies, this will have a direct

impact on the quality of mathematics learning they provide to students in the future (Mainali, 2021).

In the context of teacher education, systematic efforts are needed to strengthen students' capacity to understand and teach mathematics innovatively. One strategy that has begun to be widely developed and considered effective in increasing understanding and interest in mathematics is Project-Based Learning (PjBL) (Viro, 2020). This approach offers a more active and participatory learning model, where students are directly involved in the design and implementation of real projects related to the learning material. In mathematics learning, projects can be in the form of media development, contextual problem solving, exploration of mathematical applications in everyday life, and data processing to support decision making. PjBL helps learners build understanding of concepts through exploration, collaboration and reflection on their own experiences (Lazic, 2021).

In addition, challenges also arise from the pedagogical aspect, where teachers often do not have sufficient provision in implementing learning strategies that are varied, adaptive and in accordance with student characteristics. Limited learning resources, lack of training in the use of technology, and limited time are also obstacles in creating meaningful and contextualized mathematics learning. In fact, in the current era of industrial revolution 4.0 and society 5.0, teachers are required to be facilitators who are able to facilitate student-centered, creative, and technology based learning (Asmi, 2022).

To answer these challenges, an innovative and responsive learning approach is needed. One approach that is considered effective in overcoming mathematics learning problems is Project-Based Learning (PjBL) (Djam'an, 2021). Project-Based Learning is a learning strategy that emphasizes project-based learning activities, where students are given an active role in designing, implementing, and evaluating learning projects related to the subject matter. In the context of mathematics, this approach encourages students to relate mathematical concepts to the real world, solve real problems using mathematical skills, and build understanding of concepts through direct experience (Tyata, 2021).

Project-Based Learning provides various advantages in mathematics learning, including increasing student engagement, facilitating collaborative learning, developing 21st century skills (critical thinking, creativity, communication, collaboration), and providing space for differential learning. When students are directly involved in meaningful projects, they will find learning more relevant and interesting, thus increasing their motivation and understanding of the material. This approach also requires the role of the teacher to be an active facilitator who accompanies students in the process of exploration and discovery of concepts, rather than simply delivering the material (Susilawati, 2021).

However, the implementation of Project-Based Learning in mathematics learning will be maximized if supported by the use of digital technology. In this case, the use of digital classroom media is a strategic solution to optimize learning in the digital era. Digital classroom refers to the use of digital platforms or applications to support the learning process, either in the form of Learning Management System (LMS), online discussion forums, video conferencing, to collaborative applications such as Google Classroom, Edmodo, Zoom, and so on (Lee, 2021).The use of digital classroom enables flexible, interactive and integrated learning. Students can access materials anytime and anywhere, discuss online with lecturers and classmates, and submit assignments digitally. In the context of Project-Based Learning, the digital classroom can be used as a means of project planning, process documentation, collaboration between group members, and online presentation of project results. The integration of this technology is very

important to build learning independence, improve digital literacy, and broaden learners' horizons through access to global information (Bohara, 2024).

In the context of teacher education, it is important to equip future educators with the pedagogical and technological skills needed to teach mathematics innovatively. Students of elementary education study programs must be trained to not only understand mathematics material conceptually, but also be able to design and implement creative and technology-based learning strategies. Therefore, it is necessary to conduct research that examines the effectiveness of the combination of Project-Based Learning strategies and digital classroom media in improving the quality of mathematics learning, especially for prospective elementary school teacher students (Haatainen, 2021).

This research was conducted within the scope of the mathematics learning development course, with respondents of elementary school teacher education study program students. Students were invited to actively develop learning media based on basic math materials such as KPK, FPB, whole numbers, fractions, and flat shapes. This media development project not only trains concept understanding, but also develops students' creativity in simplifying the material into a form that is easily understood by elementary students. Before developing the media, students consult with lecturers to ensure that the media created is innovative, applicable, and in accordance with pedagogical principles. This media product can later become their professional portfolio as prospective teachers (Kim, 2021).

To support this process, learning activities do not only take place in face-to-face classrooms, but also through digital classroom media. Further discussion, assignment collection, and group collaboration are conducted online, so that students have the flexibility to develop ideas and organize projects. Lecturers act as facilitators and mentors who provide feedback and reflection on the process. In the context of 21st-century education, the landscape of mathematics learning is undergoing a significant transformation. Traditional pedagogical paradigms that rely heavily on rote memorization and procedural knowledge are being gradually replaced by more interactive, student-centered learning models (Octaviyani, 2020). These changes are driven by the growing realization that learners need not only factual knowledge but also the ability to apply mathematical thinking in real-life situations. Moreover, the increasing presence of digital technology in every aspect of life has reshaped the expectations placed upon educators and educational institutions. In this evolving educational environment, it becomes crucial to rethink how mathematics is taught, especially to pre-service teachers who will later become key agents of change in the classroom (Sinurat, 2022).

Mathematics education is no longer confined to the delivery of algorithms and formulae. It now demands deeper conceptual understanding, the ability to model real-world problems, and the integration of digital tools to enhance learning experiences (Martawijaya, 2023). In line with this shift, modern teacher education programs are expected to provide future teachers with meaningful learning opportunities that foster creativity, inquiry, and digital fluency. However, many mathematics education programs continue to fall short in these areas. The persistent reliance on teacher-centered lectures and lack of innovative pedagogical practices have led to a disconnect between theory and practice, which negatively impacts students' motivation and self-efficacy in learning mathematics (Angreanisita, 2021).This situation is particularly concerning for pre-service teachers, as their perception of mathematics and how it is learned plays a central role in shaping their future teaching approaches. If pre-service teachers do not experience engaging and relevant mathematics learning during their training, they are unlikely to implement such strategies in their own classrooms. Hence, the incorporation of contemporary teaching

methodologies such as Project-Based Learning (PjBL), which emphasizes active inquiry and collaboration, becomes an essential intervention (Diego-Mantecon, 2021).

Therefore, the integration of Project-Based Learning (PjBL) with digital classroom environments holds promising potential to address persistent challenges in mathematics learning at the elementary teacher education level. This blended approach has been shown to enhance student engagement, foster essential 21st-century competencies, and equip pre-service teachers with practical skills for their future careers (Vistara, 2022). It also aligns with current educational reform movements that emphasize inclusive, technology-oriented, and learner-centered pedagogies. However, despite these recognized benefits, there remains a limited number of studies that specifically examine how digital classroom-based PjBL is implemented in the context of elementary teacher education and how it directly impacts students' conceptual understanding and learning outcomes in mathematics. Previous research has predominantly focused on either PjBL or digital learning separately, rather than their integrated application. Therefore, this study seeks to fill this gap by investigating how the integration of digital classroom environments with PjBL can effectively improve students' understanding and engagement in mathematics learning (Simbolon, 2022).

With this combined approach, it is expected that there will be an increase in students' understanding of the material, as well as an increase in their positive attitude towards mathematics. Based on the data obtained from the questionnaire results, the majority of students felt that this strategy helped them understand the material better and made learning more interesting. This shows that the combination of Project-Based Learning and digital classroom is not only effective from the academic side, but also from the affective and motivational side (Azizah, 2020). By considering these various aspects, it can be concluded that the Project-Based Learning strategy combined with the digital classroom is an innovative and effective solution in facing the challenges of basic mathematics learning, especially in the context of teacher education. This approach not only improves the cognitive aspect of concept understanding, but also develops affective (motivation, attitude) and psychomotor (thinking and technology skills) aspects. The results of this study are expected to be an important reference for higher education institutions, lecturers teaching mathematics education courses, and policy makers in designing learning strategies that are adaptive to the needs of the times. Overall, this research aims to answer the challenges of learning mathematics in the digital era by presenting alternative strategies that are innovative, adaptive, and in accordance with the characteristics of today's learners. By combining project-based learning and digital technology, it is expected that the teaching and learning process of mathematics will be more meaningful, enjoyable, and have a long-term impact in shaping the competencies of students and prospective teachers.

METHODS

The research used in this study is developmental research on primary school mathematics strategies and challenges. The purpose of this research is to provide a deeper understanding of existing learning practices and the factors that influence their effectiveness. As well as developing adaptive mathematics learning in primary schools to adapt to the era of diffusion. This method uses a systematic, quantifiable approach that allows researchers to collect data that is analyzed statistically (Bakker, 2021). In this study, the researchers used a descriptive research design with a mutually selective approach where data was collected on a representative set of respondents.

The population of this study were all students who took mathematics courses for elementary schools at the Abuyasalek Islamic Institute. The number of respondents was 24 people. To determine the sample, the researchers used stratified sample technology on random samples, and the population was divided into layers with specific criteria. In this way, the researchers were able to confirm that the sample collected reflected the diversity of the population. The number of samples to be removed is determined based on the slobin equation to ensure representation. Data will be collected through a questionnaire specifically designed for the purpose of this study. Questions measuring the types of learning strategies used by teachers, such as contextual approaches, active methods, use of technology, and differentiation of instruction. A Likert scale of 1-5 will be used to measure how often these strategies are applied in learning. To measure students' mathematics learning outcomes, researchers will use test score data obtained by students in mathematics courses. This data will be collected with permission from the campus.

Data collection will be conducted in several stages. First, researchers will prepare research materials such as references, questionnaires and applications to measure and analyze research data. After the materials are obtained and ready, the questionnaires will be distributed to the sampled students. The researcher will provide an explanation of the purpose of the study and how to complete the questionnaire. To ensure a high participation rate, the researcher can provide sufficient time to fill out the questionnaire and ensure that all questions are well understood. After the questionnaires are collected, the researcher will perform data processing. The quantitative data collected will be analyzed using statistical software, such as SPSS or google forms. Descriptive analysis will be used to describe the characteristics of respondents and the frequency of use of learning strategies.

Data analysis in this study was conducted systematically to identify patterns and relationships between variables. First, the researchers conducted a descriptive analysis to explain the demographic data of the respondents and the frequency and percentage of using different learning strategies. In addition, the researchers tested the proposed hypotheses. Whether there is a significant difference in learning outcomes between college students who learn with different strategies.

The objective of the previous study was to examine the effectiveness of Project-Based Learning implemented through a digital classroom. To ensure methodological consistency, the study specifically measured the application and outcomes of Project-Based Learning strategies employed by teachers within the digital classroom context. This alignment strengthens the coherence between the research objectives and the methods used (Cheng, 2020).

RESULTS AND DISCUSSION

In this study, the authors developed a project-based learning strategy and added digital classroom media for interactive discussions outside the classroom. where this strategy is deemed suitable to answer the challenges that exist in learning elementary school mathematics. The respondents in this study were elementary school study program students. Then the research activities began with researchers or lecturers explaining basic mathematics material in the form of FBP, KPK, whole numbers, fractions and flat buildings. The selection of material is tailored to the needs of prospective teachers and general basic mathematics material. After explaining the material, the researcher divided the respondents into 5 groups.From the groups formed, each group chooses one of the materials that have been explained. Then each group will create a new learning media according to the selected material. Before making learning media, starting from

groups 1 to 5 consulted the title and characteristics and advantages of their media. After the lecturer approves then they are allowed to make the learning media. The purpose of the consultation is that students or respondents can make learning media that are innovative, durable and practical. The media can be used as a portfolio when they will become teachers in schools in the future. After the lecturer gave direction and input, the lecturer gave a questionnaire to test students' understanding of the material that had been explained previously. From the questionnaires distributed to respondents, researchers can evaluate current learning activities. Then the following data was obtained.

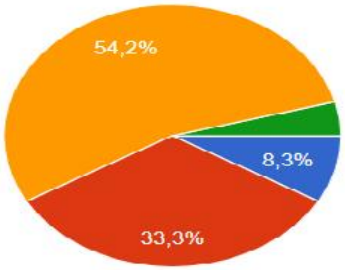

Figure 1. Data on Student Interest in Learning Mathematics

From the data above from 24 people who have filled out the questionnaire, 54.2% of respondents are interested in learning math, then 33.3% of respondents are often interested in learning math, 8.3% are very interested in learning math and 4% are rarely interested in learning math.

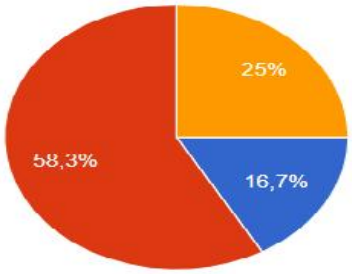

Figure 2. Data on Student Understanding of Material

From the data above, it is obtained that 58.3 really understand the mathematics material explained by the lecturer, then 25% unders.tand enough and 16.7% really understand the material explained by the lecturer.

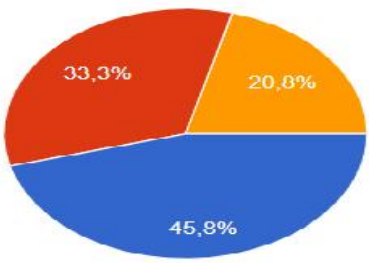

Figure 3. Student Assessment Data on the Methods Used by Lecturers

From the diagram above, it can be seen that 45.8% of respondents assessed the methods used by lecturers in learning mathematics in lecture classes. Then 33.3% rated the learning as effective. The remaining 20.8% of respondents assessed learning using methods that were quite effective.

From some of the diagrams above, it can be concluded that in the context of learning mathematics in elementary schools, the Project-Based Learning (PjBL) approach applied in this study contributes significantly to increasing students' understanding and interest in the material. This strategy emphasizes learner-centered learning, where students do not just passively receive information, but actively build understanding through involvement in real projects related to mathematics materials. When students are involved in the process of designing learning media, they not only understand the material more deeply, but also hone critical, collaborative and creative thinking skills that are very important for prospective teachers.

The use of Digital Classroom as an interactive discussion media outside the classroom also strengthens the effectiveness of this Project-Based Learning approach. With the digital platform, students have the space to collaborate, discuss and exchange ideas flexibly without being bound by time and place. This allows the learning process to be more dynamic, contextual and personalized. Students can also access supporting materials independently, explore additional learning resources, and interact with lecturers and fellow students in a more relaxed and interactive discussion format. This is in line with the demands of 21st century education which emphasizes the integration of technology in the teaching and learning process (Vinnervik, 2022).

One of the strengths of this approach is when students are asked to create learning media according to the chosen topic. This creative process requires students to really understand the content of the material because they have to simplify complicated mathematical concepts into visual or concrete forms that are easily understood by elementary school students. In addition, consultation with lecturers regarding the title and characteristics of learning media serves as academic guidance that strengthens the quality of the final product and directs students to think more systematically in designing educational media.

Quantitative data obtained through questionnaires provide a fairly clear picture of the success of this strategy. Most respondents (54.2%) expressed interest in learning mathematics after the implementation of this strategy. This indicates an important increase in learning motivation, given that math is often perceived as a difficult and challenging subject. In fact, 33.3% of respondents stated that they were often interested in learning math, and 8.3% claimed to be very interested. This indicates that adaptive learning strategies can change negative perceptions of math.

This increase in interest in learning seems to be in line with the increase in understanding of the material. From the data collected, 58.3% of respondents claimed to understand the material explained by the lecturer very well, 25% understood quite well, and 16.7% understood very well. This high level of understanding indicates that the PjBL strategy combined with digital media is not only methodically interesting, but also effective in improving learning outcomes. One of the main factors that led to this improvement was that students were challenged to re-explain the material they had learned in the form of creative and communicative learning media. This process helps to strengthen retention and concept understanding.

In addition, students' assessment of the methods used by lecturers indicated that the approach was perceived as relevant and useful. A total of 45.8% rated the method as effective, 33.3% considered it very effective, and only 20.8% viewed it as moderately effective. These findings provide empirical support that the applied strategy has a positive impact on students' learning experience. This effectiveness may be attributed to several factors, such as increased student engagement, the integration of interactive learning activities, and the alignment of the method with students’ learning needs in a digital environment. However, the success of this

strategy may also be influenced by factors such as lecturers' proficiency in implementing the method, students' digital literacy, and the availability of technological resources. Despite these positive outcomes, some limitations should be acknowledged, including potential variability in implementation across different courses, unequal access to technology among students, and the possibility that not all learners benefit equally from the approach.

The integration of theory and practice through the project of making learning media also helps students prepare themselves for the world of work as teachers. The media products produced can be used as a portfolio that shows their competence in designing innovative learning. This is important because teachers in the digital era are not only required to master the material, but also have creative pedagogical skills and be adaptive to technological changes. Furthermore, this strategy also provides space to conduct formative and summative assessments thoroughly. Lecturers as facilitators can assess the development of student understanding not only from the results of quizzes or questionnaires, but also from the process and products of learning media made. This allows for a more holistic evaluation of learning, covering cognitive, affective and psychomotor aspects.

Another advantage of using this strategy is its ability to accommodate students' different learning styles. In a group, there are students who excel in visualization, others who are more comfortable conveying ideas verbally, or writing abstract concepts. With the division of tasks within the team, each member can contribute according to his or her strengths, which ultimately increases the sense of responsibility and togetherness in achieving learning goals. However, it cannot be denied that this strategy also has its challenges. Firstly, it takes quite a long time to complete the learning project. Secondly, technology usage skills are still a barrier for some students who are not familiar with digital platforms. Therefore, simple technical training prior to implementation is highly recommended so that students can utilize technology optimally (Detyna, 2023).

This strategy also requires the active role of lecturers as facilitators who not only master the material, but also have pedagogical competence in designing appropriate and challenging project tasks. Lecturers must also be able to provide constructive feedback that encourages students to continue to improve and develop their ideas. Overall, the implementation of Project-Based Learning strategy combined with Digital Classroom proved to be effective in increasing students' motivation and understanding of basic mathematics materials. This strategy not only improves the quality of learning, but also provides meaningful and applicable learning experiences for prospective teachers. This research shows that with the right approach, challenges in mathematics learning can be overcome and even turned into opportunities for better educational innovation.

Given these results, it is recommended that higher education institutions, especially basic education study programs, start integrating project-based learning approaches in their curriculum. In addition, lecturer training on the use of digital media and active learning strategies also needs to be improved to optimize the whole learning process. As a follow-up, further research can be conducted by expanding the number of respondents, as well as comparing the effectiveness of this strategy with other approaches such as blended learning, flipped classroom, or problem-based approaches. This will provide a more comprehensive picture of which strategies are most effective in the context of learning mathematics at the primary level.

Another critical consideration is the potential of this blended strategy to cultivate a mindset of lifelong learning among pre-service teachers. By being actively involved in

designing, discussing, and implementing learning projects using digital tools, students are not only acquiring academic knowledge, but also internalizing the habits of inquiry, reflection, and adaptability qualities that are fundamental to professional growth in the field of education. These habits prepare them to be teachers who are not merely transmitters of knowledge, but facilitators of learning who are responsive to their students' needs and evolving educational contexts.

Another benefit that emerged from the implementation of this approach is the enhancement of peer learning. Through collaborative digital platforms, students are exposed to diverse perspectives and strategies, fostering a rich learning environment where they learn from each other's ideas, mistakes, and problem-solving methods. This kind of social constructivist learning model encourages active dialogue and shared meaning-making, which is crucial in developing deeper conceptual understanding. It also simulates the dynamics of professional learning communities, preparing students to participate in similar collaborative environments in their future schools.

Nevertheless, this model also brings several implications that must be addressed institutionally. First, there is a clear need for teacher education institutions to invest in the infrastructure that supports blended learning environments. Stable internet access, access to collaborative software, and digital literacy training must be prioritized to ensure that all students can fully engage in the learning process. Furthermore, educators must be continuously trained to design and facilitate project-based and technology-supported learning. Without adequate preparation and institutional support, even the most promising pedagogical models may fail to reach their full potential.

Additionally, it is essential to consider how assessment methods can be adapted to capture the multifaceted learning outcomes associated with this strategy. Traditional assessments that focus solely on individual test scores may not fully reflect the collaborative, creative, and process-oriented nature of project-based learning. Alternative assessment methods such as digital portfolios, peer evaluations, process journals, and performance-based tasks should be integrated to provide a more comprehensive picture of student learning. These methods also align well with the development of 21st-century competencies, offering authentic measures of students' ability to apply their knowledge in real-world contexts(Aldhafeeri, 2022).

Importantly, the impact of such a blended learning approach extends beyond academic performance. It contributes to the emotional and social development of learners by promoting confidence, autonomy, and resilience. When students are given the responsibility to take charge of their own learning process selecting topics, designing media, solving problems, and communicating their ideas they develop a sense of ownership that increases intrinsic motivation. This internal drive is vital in overcoming challenges commonly associated with mathematics learning, such as anxiety, low self-efficacy, and disengagement.

Furthermore, this study illustrates how the synergy between digital tools and project-based tasks can be effectively leveraged to localize mathematics education. Students are encouraged to incorporate real-life problems and culturally relevant content into their projects, making mathematics more relatable and meaningful to learners in specific community contexts. This localized approach not only enriches the educational experience but also helps future teachers recognize the importance of culturally responsive pedagogy an essential component of inclusive education in diverse classroom settings(Feng, 2024).

In future implementations, it is recommended to establish stronger feedback loops between students and instructors throughout the project development process. This can be facilitated through periodic online check-ins, progress presentations, and collaborative reflection

sessions. These iterative interactions can help ensure that students remain on track, maintain the quality of their output, and refine their understanding continuously. It also allows lecturers to adjust the scaffolding according to students' developmental needs, thereby enhancing both individual learning trajectories and group performance.

Finally, while this study has shown promising results, broader research is necessary to further validate and generalize the findings. Longitudinal studies tracking the impact of digital PjBL on student outcomes over time both during teacher education and into their in-service teaching careers would be especially valuable. Comparative studies involving different subject areas, institutions, or student populations could also uncover contextual factors that influence the success of such strategies. By expanding the evidence base, educators and policymakers can make more informed decisions on how to scale and sustain effective teaching innovations in the digital era.

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the application of Project-Based Learning (PjBL) strategies combined with the use of digital classroom media has proven effective in increasing students' understanding and interest in learning basic mathematics courses. This strategy is able to create a learning atmosphere that is more active, participatory, and relevant to the needs of education in the digital era. Through direct involvement in learning media creation projects, students not only learn to understand mathematical materials such as FPB, KPK, whole numbers, fractions, and flat shapes more deeply, but also develop critical thinking, creative, collaborative, and communication skills which are important skills for prospective teachers. The learning media products produced can also be used as a valuable portfolio to support their professional careers in the future. The use of digital classroom also provides flexibility and accessibility in the learning process. Students can discuss, collaborate and access materials independently anytime and anywhere. This provides a broader learning experience and encourages the formation of independence and high digital literacy among students.

Quantitative data showed that most students expressed an increase in their interest and understanding of mathematics learning after following this strategy. This reinforces the assumption that a contextual and technology-based learning approach can overcome negative perceptions of mathematics and build positive learning motivation. Thus, this digital-based Project-Based Learning strategy is highly recommended to be integrated into the teacher education curriculum, especially in mathematics learning development courses. This strategy can be an innovative solution to the challenges of learning mathematics in elementary schools, while equipping prospective teachers with pedagogical and technological competencies that are relevant to the demands of 21st century education.

Quantitative findings indicate that most students demonstrated increased interest and improved understanding of mathematics after the implementation of this strategy. This supports the view that a contextual, technology-enhanced learning approach can mitigate negative perceptions of mathematics and foster positive learning motivation. Accordingly, digital-based Project-Based Learning (PjBL) offers a promising approach for integration into teacher education curricula, particularly in mathematics education courses, as it promotes both pedagogical and technological competencies aligned with 21st-century educational demands.

Nevertheless, this study is not without limitations. The relatively small and context-specific sample restricts the generalizability of the findings. In addition, the reliance on

quantitative data limits a deeper understanding of students' learning experiences, while the short intervention period constrains the ability to capture long-term effects. Future research should address these limitations by employing larger and more diverse samples, as well as adopting mixed-method designs to provide more comprehensive insights. Longitudinal studies are also needed to examine the sustained impact of digital-based PjBL on students' mathematical achievement, motivation, and the professional development of pre-service teachers.

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