

SYNERGY BETWEEN SCIENCE AND TECHNOLOGY IN ENHANCING THE COMPETENCIES OF ELEMENTARY MADRASAH TEACHER EDUCATION STUDENTS

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Abstract: This study aims to analyze the synergy between science and technology in enhancing the competencies of Elementary Madrasah Teacher Education students at STAI Al-Falah Banjarbaru. This study employs a qualitative approach with a descriptive design. Data collection techniques included observation, interviews, and documentation of students and faculty members. Data analysis involved the stages of data reduction, data presentation, and drawing conclusions to obtain a systematic overview of the phenomenon under study. The results indicate that the integration of science and technology contributes to enhancing students' pedagogical, professional, and digital literacy competencies. Students demonstrated improved abilities in designing technology-based learning, integrating scientific concepts into instructional materials, and effectively utilizing digital media. However, several challenges were identified, including limited supporting facilities and varying levels of technological proficiency among students. Thus, the synergy between science and technology plays a crucial role in supporting the enhancement of competencies among students in the Elementary Madrasah Teacher Education program. Therefore, strategic efforts are needed from the institution to strengthen infrastructure support and ensure the continuous development of students' capacities.

Keywords: Elementary Madrasah Teacher Education, Science, Technology, Student Competencies.

Abstrak: Penelitian ini bertujuan untuk menganalisis sinergi sains dan teknologi dalam meningkatkan kompetensi mahasiswa Pendidikan Guru Madrasah Ibtidaiyah di STAI Al-Falah Banjarbaru. Penelitian ini menggunakan pendekatan kualitatif dengan jenis deskriptif. Teknik pengumpulan data dilakukan melalui observasi, wawancara, dan dokumentasi terhadap mahasiswa dan dosen. Analisis data menggunakan tahapan reduksi data, penyajian data, dan penarikan kesimpulan untuk memperoleh gambaran yang sistematis mengenai fenomena yang diteliti. Hasil penelitian menunjukkan bahwa integrasi sains dan teknologi berkontribusi terhadap peningkatan kompetensi pedagogik, profesional, dan literasi digital mahasiswa. Mahasiswa menunjukkan kemampuan yang lebih baik dalam merancang pembelajaran berbasis teknologi, mengintegrasikan konsep sains dalam materi ajar, serta memanfaatkan media digital secara efektif. Namun demikian, terdapat beberapa kendala, antara lain keterbatasan fasilitas pendukung dan perbedaan tingkat penguasaan teknologi di kalangan mahasiswa. Dengan demikian, sinergi sains dan teknologi memiliki peran penting dalam mendukung peningkatan kompetensi mahasiswa Pendidikan Guru Madrasah Ibtidaiyah. Oleh karena itu, diperlukan upaya strategis dari institusi untuk memperkuat dukungan sarana prasarana serta pengembangan kapasitas mahasiswa secara berkelanjutan.

Kata Kunci: Pendidikan Guru Madrasah Ibtidaiyah, Sains, Teknologi, Kompetensi Mahasiswa.

Introduction

Advances in science and technology in the 21st century have brought significant changes to the world of education, particularly by requiring mastery of multidimensional competencies that encompass pedagogical, professional, and digital literacy aspects. This transformation positions education not merely as a process of knowledge transfer, but as an integrative space that connects science, technology, and contextual learning practices. The integration of science and technology has become a fundamental necessity in shaping students' competencies, particularly at the Elementary Madrasah Teacher Education level at STAI Al-Falah Banjarbaru, which plays a strategic role in building the

foundation of basic education.

Numerous studies indicate that the integration of science and technology particularly through STEM approaches and digital technology can enhance critical thinking skills, creativity, and problem-solving abilities in learning. A bibliometric study of Scopus publications indicates a significant increase in research related to STEM education in recent years, underscoring the urgency of such integration in modern education systems.¹ Additionally, research based on systematic literature reviews also shows that the use of digital technology in science learning contributes positively to learning effectiveness and increased student engagement.²

Other studies have revealed that the integration of educational technology into elementary education can improve the quality of learning interactions, but it still faces various challenges such as infrastructure limitations, the digital divide, and low levels of educators' technological competence.³ Similar findings also indicate that the integration of science literacy and digital technology has the potential to improve the quality of learning, but its implementation has not been optimal due to resource constraints and user readiness.⁴ This highlights a gap between the theoretical potential of science and technology integration and its practical implementation in the field. Based on these studies, the research gap lies in the limited number of empirical studies that specifically examine the synergy of science and technology in the context of elementary madrasah teacher education, particularly at the level of religious higher education institutions. Most research still focuses on elementary school students or general education, so few studies have highlighted how prospective teachers internalize this integration into their competencies. The novelty of this study lies in its analytical focus on the

¹ Bagus Pratomo Nusantoro, Paidi Hw, dan Kintan Limiansi, *Mapping Publication Trends dalam Pendidikan STEM* dari Database Scopus: Analisis Bibliometrik, SAP (Susunan Artikel Pendidikan), Vol. 10 No. 3, Universitas Negeri Yogyakarta, 2026, h. 410.

² A. M. H. Taufiq, *Integrasi Artificial Intelligence dalam Pembelajaran Sains: Systematic Literature Review terhadap Artikel Terindeks Scopus 2023–2025*, Jurnal Pendidikan, 2026, h. 1-10.

³ Fathiyah Rachmah, Niken Widy Astuti, dan Arum Fatayan, *Integrasi Teknologi Pendidikan untuk Meningkatkan Kualitas Pembelajaran Interaktif di Sekolah Dasar Indonesia*, Didaktik: Jurnal Ilmiah PGSD STKIP Subang, Vol. 11 No. 3, 2025, h. 258-259.

⁴ Nurul Aisyah, dkk., *Integrasi Literasi Matematika dan Sains dalam Pendidikan Berbasis Teknologi Digital*, Jurnal Pengabdian Masyarakat dan Riset Pendidikan, Vol. 4 No. 2, 2025, h. 9661-9662.

synergy between science and technology in enhancing the competencies of Elementary Madrasah Teacher Education students within religious higher education institutions, using an approach that examines pedagogical, professional, and digital literacy aspects in an integrated manner. This study is expected to provide conceptual and practical contributions to the development of a learning model based on the integration of science and technology.

The objective of this study is to conduct an in-depth analysis of how the synergy between science and technology plays a role in enhancing the competencies of Madrasah Ibtidaiyah Teacher Education students at STAI Al-Falah Banjarbaru, as well as to identify the supporting and inhibiting factors in its implementation.

Research Methodology

Metode This study employs a qualitative approach using a descriptive research design, aiming to gain an in-depth understanding of the phenomenon of science and technology synergy in enhancing the competencies of Elementary Madrasah Teacher Education students at STAI Al-Falah Banjarbaru. This approach was chosen because it can comprehensively describe empirical realities and provide room for interpretation of the dynamics occurring in the learning process.

The research was conducted at STAI Al-Falah Banjarbaru, South Kalimantan. The study spanned three months, from January to March 2024. The research subjects included Elementary Madrasah Teacher Education students and faculty members involved in science and technology-based learning processes. Data collection was conducted using three main methods: observation, in-depth interviews, and documentation.⁵ Observation was used to directly observe the learning process and the use of technology in academic activities. Interviews were used to gather more in-depth information regarding the experiences, perceptions, and challenges faced by students and faculty members. Documentation was carried out by collecting supporting data such as learning tools, digital media, and relevant academic activity records.

Data analysis was conducted using an interactive analysis model comprising three stages: data reduction, data presentation, and drawing

⁵ Uwe Flick, *An Introduction to Qualitative Research*, Sage Publications, 2023, h. 89.

conclusions.⁶ Data reduction was performed by selecting and simplifying data relevant to the research focus. Data presentation was done in the form of descriptive narratives to ensure ease of understanding. Subsequently, conclusions were drawn gradually based on patterns and findings that emerged during the analysis process. To ensure data validity, this study employed source and method triangulation, thereby ensuring that the obtained data possess a high level of validity and reliability.

Results and Discussion

This section outlines the research findings obtained from the process of collecting and analyzing data related to the synergy between science and technology in enhancing the competencies of Elementary Madrasah Teacher Education students at STAI Al-Falah Banjarbaru. The findings presented not only reveal empirical facts from the field but also highlight patterns emerging from the interactions among students, faculty members, and the use of technology in the learning process. Furthermore, these results are systematically interpreted to address the research questions, while also being linked to relevant theories and previous research findings. Thus, the discussion in this section is not merely descriptive but also analytical and reflective, aiming to build a more comprehensive understanding.

Improving Pedagogical Competence

The results of the study indicate that the synergy between science and technology significantly contributes to improving the pedagogical competencies of students in the Elementary Madrasah Teacher Education program at STAI Al-Falah Banjarbaru. The pedagogical competencies in question include the ability to effectively design, implement, and evaluate learning by utilizing science- and technology-based approaches. Students demonstrated improvement in developing more systematic lesson plans, particularly in integrating science concepts into contextual teaching materials.⁷

In addition, the use of digital technology in the learning process encourages students to be more creative in choosing learning strategies and methods. Students have begun to use various digital media, such as interactive

⁶ Matthew B. Miles, A. Michael Huberman, dan Johnny Saldana, *Qualitative Data Analysis: A Methods Sourcebook*, Sage Publications, 2024, h. 12-14.

⁷ Huda Miftahul, dkk., *Integrating STEM Education to Enhance Pedagogical Competence in Teacher Education Programs*, Springer, 2024, h. 112.

presentation applications, educational videos, and online learning platforms, to increase student engagement.⁸ This demonstrates that technology functions not only as a tool but also as an integral part of the development of students' pedagogical competencies. Other findings indicate that the integration of science and technology helps students understand learner characteristics and adapt their teaching approaches accordingly.

Students become better able to develop student-centered learning, making the learning process more active, participatory, and meaningful. This improvement is also reflected in students' ability to reflect on and evaluate the learning processes they have implemented.⁹ Thus, the results of this study confirm that the synergy between science and technology plays a strategic role in enhancing students' pedagogical competencies. Systematic integration encourages students to develop teaching skills that are adaptive and relevant to the demands of 21st-century education.

Professional Development

The results of the study indicate that the synergy between science and technology makes a significant contribution to enhancing the professional competencies of students in the Elementary Madrasah Teacher Education program at STAI Al-Falah Banjarbaru. Professional competencies in this study are demonstrated through mastery of science-based teaching materials and the ability to integrate technology into the learning process.¹⁰ Students not only understand scientific concepts theoretically but are also able to apply them to the learning context in elementary madrasahs.

Students demonstrated improvement in their ability to develop innovative digital teaching materials. They began utilizing various software and learning platforms to create engaging and interactive learning media, such as digital modules, instructional videos, and the use of learning management systems.¹¹ This indicates that technology has become an essential component in supporting the professionalism of prospective teachers.

⁸ Li Zhang dan Chen Wei, *Digital Technology Integration in Teacher Education: Impacts on Pedagogical Skills*, Routledge, 2023, h. 78-79.

⁹ Nur Afifah, dkk., *Student-Centered Learning in Digital Era: Improving Pedagogical Competence of Pre-Service Teachers*, Elsevier, 2025, h. 56.

¹⁰ John Voogt, Natalie Pareja Roblin, dan Jules Pieters, *Teacher Professional Competence in the Digital Age*, Springer, 2024, h. 134.

¹¹ Maria Ranieri dan Stefania Manca, *Digital Media in Teacher Education: Professional Development and Teaching Practices*, Routledge, 2023, h. 95-96.

The integration of science and technology also encourages students to improve their ability to adapt to advancements in science and technology. Students become more open to new information and are able to engage in continuous self-development. These competencies serve as key indicators for meeting the increasingly complex demands of the teaching profession in the digital age.¹² However, this study also found that improvements in professional competencies are not yet uniform across all students. Differences in background and levels of technological proficiency are among the factors affecting the optimization of these competencies. Therefore, more targeted learning strategies are needed to ensure that all students can achieve the expected professional competency standards.

Improving Digital Literacy and Implementation Challenges

Research findings indicate that the synergy between science and technology contributes to improving the digital literacy of students in the Elementary Madrasah Teacher Education program at STAI Al-Falah Banjarbaru. Students' digital literacy is evident in their ability to effectively access, understand, evaluate, and utilize technology-based information in academic activities.¹³ Students have become accustomed to using various digital learning resources, such as scientific journals, online learning platforms, and educational applications to support the learning process.

In addition, students also demonstrate improvement in their ability to critically manage information, including identifying credible sources relevant to their learning needs. This indicates that digital literacy extends beyond technical skills to encompass cognitive and ethical aspects of technology use.¹⁴ The appropriate use of technology also encourages students to become more independent in their learning and better able to adapt to the rapid pace of information development.

This study also identified challenges in the implementation of digital literacy. One of the main challenges is the limited availability of technological resources, both in terms of hardware and internet access. This situation results in suboptimal use of technology in learning. Additionally, there are disparities

¹² Ahmed Tlili, Ronghuai Huang, dan Kinshuk, *Emerging Technologies for Education: Professional Competence and Innovation*, Elsevier, 2025, h. 67.

¹³ Neil Selwyn, *Digital Education in a Changing World: Advances and Challenges*, Routledge, 2023, h. 54.

¹⁴ Allison Littlejohn, Nina Hood, dan Chris Milligan, *Digital Literacy and Learning in Higher Education*, Springer, 2024, h. 88-89.

in technological proficiency among students, leading to inequalities in digital literacy skills.¹⁵

Another challenge identified is the lack of systematic training in the use of educational technology. Some students still face difficulties in operating specific applications or effectively integrating technology into learning. This indicates that improving digital literacy requires sustained support, both from the institutional level and through the development of individual students' capacities. Thus, although students' digital literacy has improved, strategic efforts are still needed to address the various existing challenges so that the integration of science and technology can proceed optimally.

Interpreting Competency Development from a Theoretical Perspective

The development of competencies among students in the Elementary Madrasah Teacher Education program at STAI Al-Falah Banjarbaru can be interpreted through the perspective of constructivist theory, which emphasizes that knowledge is actively constructed by individuals through learning experiences. In this context, the integration of science and technology provides students with the opportunity not only to receive information but also to construct understanding through exploration, problem-solving, and the use of technology as a learning tool.¹⁶ Thus, the learning process becomes more meaningful as it involves the interaction between conceptual knowledge and practical experience.

This enhancement of competencies aligns with the 21st-century learning framework, which emphasizes the importance of mastering critical thinking, creativity, collaboration, and communication skills. The integration of science and technology encourages students to develop these skills simultaneously.¹⁷ Students are not only required to understand scientific concepts but also to communicate ideas, work collaboratively in teams, and utilize technology to support the learning process.

From the perspective of digital literacy theory, the improvement in students' competencies indicates that their ability to use technology is not limited to technical aspects but also encompasses cognitive and social skills.

¹⁵ Dirk Ifenthaler dan Dana-Kristin Mah, *Digital Transformation of Education: Challenges and Opportunities*, Springer, 2025, h. 102.

¹⁶ Lev S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, Harvard University Press, edisi terbaru 2024, h. 79.

¹⁷ Bernie Trilling dan Charles Fadel, *21st Century Skills: Learning for Life in Our Times*, Wiley, edisi pembaruan 2023, h. 48-49.

Students are able to critically access, evaluate, and utilize information, thereby supporting the integrated development of pedagogical and professional competencies.¹⁸ This demonstrates that digital literacy is an integral part of developing prospective teachers' competencies in the digital age.

The results of this study indicate that the integration of science and technology can be understood as an integrative learning approach that combines various domains of knowledge. This approach not only strengthens conceptual understanding but also encourages students to develop adaptive skills in response to change. Thus, the improvement in students' competencies is not merely linear but also holistic and sustainable.

Confirmation and Modification of Previous Research Findings

The results of this study confirm previous research findings that emphasize how integrating technology into learning positively contributes to improving the quality of both the learning process and outcomes. In this context, the use of technology not only enhances the effectiveness of content delivery but also expands access to more diverse and interactive learning resources.¹⁹ These findings reinforce the view that technology plays a strategic role in supporting the development of prospective teachers' competencies in the digital age. However, this study also contributes by modifying previous findings. While some earlier studies tended to position technology as an instructional tool, the results of this study indicate that technology and science need to be positioned integrally as a single unit within the learning process.²⁰ The synergy between the two not only enhances students' cognitive aspects but also simultaneously strengthens their pedagogical and professional competencies.

This study offers a new perspective by positioning elementary school teacher education students as the primary subjects in the integration of science and technology. Most previous studies have focused more on students at the elementary or secondary school levels, so research on prospective teachers remains relatively limited. Therefore, this study broadens the scope of the research by demonstrating that the integration of science and technology from

¹⁸ Eszter Hargittai dan Amanda Hinnant, *Digital Literacy in Education and Society*, MIT Press, 2024, h. 112.

¹⁹ Neil Selwyn, *Education and Technology: Key Issues and Debates*, Bloomsbury Academic, 2023, h. 67.

²⁰ Ronghuai Huang, Kinshuk, dan Mohamed Ally, *Transforming Education with Emerging Technologies*, Springer, 2024, h. 142.

the teacher education stage has a significant impact on future professional readiness.²¹ Furthermore, this study also modifies previous approaches by emphasizing the importance of holistic, rather than partial, integration. The integration of science and technology is not only applied to the use of learning media but also in the planning, implementation, and evaluation of learning. Thus, the results of this study point toward the development of a new paradigm in teacher education that positions the integration of science and technology as the primary foundation for competency development.

Theoretical and Practical Implications

The results of this study offer important theoretical implications for the development of educational research, particularly regarding the integration of science and technology in teacher education. The findings indicate that the synergy between science and technology is inseparable from the development of students' competencies, thereby reinforcing the concept of integrative learning as a relevant approach in the digital age. From a theoretical perspective, these results expand the constructivist learning framework by incorporating the technological dimension as part of the knowledge-construction process.²² Consequently, learning is not only focused on conceptual understanding but also on the ability to apply knowledge through the effective use of technology.

This study contributes to the development of digital literacy theory within the context of teacher education. Digital literacy is no longer understood as an additional skill but rather as a core competency that prospective teachers must possess. The integration of science and technology in learning fosters the development of holistic competencies, encompassing cognitive aspects, skills, and professional attitudes²³. This indicates the need for a reconstruction of the teacher education curriculum that systematically accommodates such integration.

The findings of this study have direct implications for educational institutions, particularly STAI Al-Falah Banjarbaru, in designing learning policies and strategies. Institutions need to provide support in the form of

²¹ John Voogt dan Natalie Pareja Roblin, *Teacher Education in the Digital Age: Pedagogical and Technological Integration*, Routledge, 2025, h. 88.

²² Dirk Ifenthaler dan Dana-Kristin Mah, *Digital Transformation of Education: Concepts and Practices*, Springer, 2024, h. 55.

²³ Allison Littlejohn, Nina Hood, dan Chris Milligan, *Reimagining Digital Learning in Higher Education*, Springer, 2023, h. 101.

adequate technological facilities, such as digital learning devices and stable internet access, to support the implementation of science and technology integration. In addition, ongoing training and mentoring programs are needed for students and faculty to enhance their competencies in utilizing educational technology.²⁴ Another practical implication is the need to develop a structured learning model based on the integration of science and technology. This model must be able to accommodate 21st-century learning needs and encourage students to be active, creative, and adaptive in facing change. Thus, the results of this study not only contribute to theoretical development but also serve as a foundation for formulating more relevant and sustainable educational policies and practices.

Conclusion

Based on the research findings, it can be concluded that the synergy between science and technology plays a significant role in enhancing the competencies of Elementary Madrasah Teacher Education students at STAI Al-Falah Banjarbaru. This improvement is evident in the areas of pedagogical, professional, and digital literacy competencies, which have developed in an integrated manner. Students demonstrated improved ability in designing technology-based learning, integrating scientific concepts contextually, and effectively utilizing digital media in the learning process. Additionally, the enhancement of digital literacy strengthens students' ability to access, evaluate, and use information critically.

This study also revealed challenges in implementation, such as limited infrastructure and varying levels of technological proficiency among students, which hinder the optimal integration of science and technology. Overall, the results of this study confirm that the integration of science and technology not only improves the quality of students' competencies but also serves as a crucial foundation for preparing adaptive and professional prospective teachers in the digital age. Therefore, sustained institutional support is necessary to ensure that such integration can be implemented effectively and equitably.

²⁴ Ahmed Tlili, Ronghuai Huang, dan Kinshuk, *Innovating Teacher Education through Technology Integration*, Elsevier, 2025, h. 73.

Bibliography

- A. M. H. Taufiq, "Integrasi Artificial Intelligence dalam Pembelajaran Sains: Systematic Literature Review terhadap Artikel Terindeks Scopus 2023-2025", *Jurnal Pendidikan*, 2026.
- Afifah, Nur, dkk., *Student-Centered Learning in Digital Era: Improving Pedagogical Competence of Pre-Service Teachers*, Elsevier, 2025.
- Aisyah, Nurul, dkk., *Integrasi Literasi Matematika dan Sains dalam Pendidikan Berbasis Teknologi Digital*, *Jurnal Pengabdian Masyarakat dan Riset Pendidikan*, 2025.
- Allison Littlejohn, Nina Hood, Chris Milligan, *Digital Literacy and Learning in Higher Education*, Springer, 2024.
- Bernie Trilling, Charles Fadel, *21st Century Skills: Learning for Life in Our Times*, Wiley, 2023.
- Dirk Ifenthaler, Dana-Kristin Mah, *Digital Transformation of Education: Challenges and Opportunities*, Springer, 2025.
- Eszter Hargittai, Amanda Hinnant, *Digital Literacy in Education and Society*, MIT Press, 2024.
- Flick, Uwe, *An Introduction to Qualitative Research*, Sage Publications, 2023.
- Huang, Ronghuai, Kinshuk, Mohamed Ally, *Transforming Education with Emerging Technologies*, Springer, 2024.
- Huda, Miftahul, dkk., *Integrating STEM Education to Enhance Pedagogical Competence in Teacher Education Programs*, Springer, 2024.
- Matthew B. Miles, A. Michael Huberman, Johnny Saldana, *Qualitative Data Analysis: A Methods Sourcebook*, Sage Publications, 2024.
- Neil Selwyn, *Digital Education in a Changing World: Advances and Challenges*, Routledge, 2023.
- Nusantoro, Bagus Pratomo, Paidi Hw, Kintan Limiansi, *Mapping Publication Trends dalam Pendidikan STEM dari Database Scopus: Analisis Bibliometrik, SAP (Susunan Artikel Pendidikan)*, Universitas Negeri Yogyakarta, 2026.
- Rachmah, Fathiyah, Niken Widy Astuti, Arum Fatayan, "Integrasi Teknologi

Pendidikan untuk Meningkatkan Kualitas Pembelajaran Interaktif di Sekolah Dasar Indonesia", *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, 2025.

Ranieri, Maria, Stefania Manca, *Digital Media in Teacher Education: Professional Development and Teaching Practices*, Routledge, 2023.

Tlili, Ahmed, Ronghuai Huang, Kinshuk, *Emerging Technologies for Education: Professional Competence and Innovation*, Elsevier, 2025.

Voogt, John, Natalie Pareja Roblin, Jules Pieters, *Teacher Professional Competence in the Digital Age*, Springer, 2024.

Vygotsky, Lev S., *Mind in Society: The Development of Higher Psychological Processes*, Harvard University Press, 2024.

Zhang, Li, Chen Wei, *Digital Technology Integration in Teacher Education: Impacts on Pedagogical Skills*, Routledge, 2023.