ARTIFICIAL INTELLIGENCE AS AN EDUCATIONAL INTERVENTION TO ENHANCE SELF-EFFICACY AND ACADEMIC RESILIENCE OF TEACHERS AT SENIOR HIGH SCHOOL

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ABSTRACT

Indonesia's digital transformation has developed rapidly in recent years. One form of technology that is increasingly being integrated into the field of education is Artificial Intelligence (AI). Teachers' readiness to understand and utilize this technology has become highly crucial. Self-efficacy and academic resilience are key factors that enable teachers to remain productive and adaptive. This study aimed to analyze the effect of AI training interventions on teachers' self-efficacy and academic resilience. This research employed a pre-experimental method with a one-group pretest–posttest design. The sample in this study comprised 30 respondents. The instruments used were the General Self-Efficacy Scale (GSES) and the Academic Resilience Scale (ARS-30). Data were analyzed using SPSS version 25 with a significance level of α = 0.05 and a confidence level of 95%. Normality testing was conducted using the Shapiro–Wilk test, followed by analysis using the Wilcoxon test. The results indicated significant differences in self-efficacy and academic resilience scores before and after the intervention. This finding demonstrates that AI training effectively improved teachers' confidence and academic resilience in using educational technology, highlighting the importance of conducting continuous training programs.

Keywords: Artificial Intelligence, Self Efficacy, Academic Resilience, Teacher

INTRODUCTION

Entering the era of Society 5.0, technological advancements have become increasingly sophisticated and are deeply integrated into various aspects of human life. One of the most significant developments is the widespread use of Artificial Intelligence (AI), which has emerged as a crucial tool across multiple sectors, including education. AI is capable of simulating human cognitive functions such as learning, problem-solving, and decision-making. Therefore, as a result of ongoing technological advancements, AI should be effectively utilized to enhance human performance, particularly in education. In STEM (Science, Technology, Engineering, and Mathematics) education, digital transformation plays a vital role in preparing future generations to remain competitive in the era of the Society 5.0 era. The integration of AI into learning processes not only enriches instructional

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content and delivery methods but also fundamentally transforms educational paradigms by enabling personalized, data-driven, and adaptive learning environments (Wardani et al., 2023).

However, the integration of AI into the educational curriculum continues to face significant structural and implementation challenges. A report by the Ministry of Education, Culture, Research, and Technology (2023) states that only 38% of STEM teachers in Indonesia are trained in the use of digital technology for learning, with greater disparities in non-urban areas (Johnson et al., 2024). Technologies such as AI are still hindered by limited technical training and insufficient psychosocial support to maximize their potential. This phenomenon is exacerbated by insufficient psychological support for teachers in adapting to technological changes, as revealed in a study by Lee et al. (2022) in Southeast Asia (Park, 2022; Johnson, 2024).

The latest data from the Ipsos Global Education Monitor (2023), 79% of Indonesian respondents considered teaching artificial intelligence (AI) in schools important, while 54% believed that technology, including AI, would have a positive impact on teaching and learning. These findings indicate public recognition of the potential role of AI in education in Indonesia. However, positive perceptions alone do not necessarily reflect the extent to which AI has been integrated into classroom practices. Therefore, strengthening teachers' self-efficacy and academic resilience is important to support their readiness to adopt AI-based educational practices effectively.

Furthermore, artificial intelligence (AI) offers potential benefits for teaching and learning, teachers' confidence in understanding and using AI remains an important consideration. A survey of 218 certified educators in Semarang Regency, Indonesia, found that 64% of respondents had previously used AI-based tools, while only 27% reported confidence in understanding basic AI principles (Suryani et al., 2026). These findings highlight the importance of strengthening teachers' AI literacy and confidence to support the effective integration of AI into educational practices.

Globally, UNESCO (2022) emphasizes that the success of educational digital transformation depends not only on infrastructure but also oncomprehensive teacher capacity building, including aspects of self-efficacy and academic resilience (Rahmawati et al., 2023). Unfortunately, existing training interventions have primarily focused on technical aspects, with limited attention to psychological dimensions. Research by Zhang et al. (2021) in China demonstrated that practice-based simulation training increased teachers' self-efficacy by 25%, but did not assess its impact on academic resilience.

The urgency of this research is further reinforced by a recent report from the World Economic Forum (2024), which identifies AI literacy as one of the five critical skills needed in the global job market over the coming decade. This implies that STEM teachers, as facilitators of learning for future generations, require not only technical competence in AI but also psychological readiness to integrate it into instruction. The phenomenon of "AI anxiety" currently affecting educators in various countries must be addressed through structured, evidence-based educational interventions (Henderson et al., 2023).

Furthermore, this study is conducted within the context of the implementation of the Merdeka Curriculum, which grants teachers broader autonomy to innovate in learning. Without interventions to enhance teachers' self-efficacy and academic resilience in using AI, this autonomy risks being

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underutilized. This is supported by the findings of Amalia et al. (2023), which indicate that 76% of teachers in Indonesia feel unprepared to implement AI-based learning despite having curricular autonomy (Amalia et al., 2024).

The purpose of this study is to enhance teachers' capacity and readiness to implement AI-based learning in STEM education in the Society 5.0 era, through a structured, practice-based workshop on the use of AI. Specifically, this study aims to assess changes in teachers' self-efficacy and academic resilience before and after participating in the AI-based training intervention. Self-efficacy refers to teachers' beliefs in their ability to manage challenges and accomplish tasks, while academic resilience refers to their ability to adapt and persist when facing difficulties in the professional learning context. Using a pretest–posttest approach, this study seeks to determine whether the AI-based training intervention is associated with significant changes in these two psychological variables.

Using a pre-test and post-test approach, this study is expected to provide empirical evidence regarding the effectiveness of AI workshops in enhancing STEM teachers' ability to innovate in alignment with the Merdeka Curriculum. Furthermore, this project supports the achievement of Sustainable Development Goals (SDGs), namely Goal 3 on healthy and prosperous lives, Goal 4 on inclusive, adaptive, and sustainable quality education, and Goal 9 on innovation.

METHOD

This study employed a pre-experimental design using a one-group pretest–posttest approach to evaluate the effects of Artificial Intelligence (AI) training on teachers' self-efficacy and academic resilience at SMAN 1 Batu. The study involved 30 teachers selected through total sampling. The intervention included hands-on training using Gemini and ChatGPT to develop teaching materials, generate assessment questions, and design learning activities. The training combined demonstrations and practical exercises to help teachers integrate AI into educational practices.

The study aimed to determine the effect of an intervention in the form of Artificial Intelligence (AI) training on teachers' levels of self-efficacy and academic resilience in adapting to the digital transformation of STEM learning. The variables measured were teachers' levels of self-efficacy and academic resilience. The instruments used to measure self-efficacy and academic resilience were the General Self-Efficacy Scale (GSES) and the Academic Resilience Scale (ARS-30), consisting of 10 and 30 items, respectively. The GSES used a four-point response scale: 1 = not at all true, 2 = hardly true, 3 = moderately true, and 4 = exactly true. The ARS-30 used a five-point response scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. Instrument validity was assessed using significance testing, yielding p-values of 0.005 for the GSES and less than 0.001 for the ARS-30.

Instrument reliability was calculated using Microsoft Excel by determining the variance of each item and the total score, followed by calculating Cronbach's alpha using the formula $\alpha = [k/(k-1)] \times [1 - (\Sigma Si^2/St^2)]$, where k represents the number of items, ΣSi^2 represents the sum of the item variances, and St^2 represents the variance of the total scores. Ethical approval was obtained under reference number 311/UN10.F17.10.4/TU/2025. Both instruments were presented in the form of a 5-point Likert scale, where 1 indicated "strongly disagree" and 5 indicated "strongly agree." This study was conducted in October 2025 through face-to-face sessions at SMAN 1 Batu.

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The sampling technique used was total sampling, with the study population consisting of 30 active teachers who met the following inclusion criteria: (1) teachers actively employed at SMAN 1 Batu; (2) willingness to participate in the training from beginning to completion; and (3) completion of both the pretest and posttest instruments in full. Therefore, the study population comprised all 30 participating teachers at SMAN 1 Batu, rather than exclusively STEM teachers. Accordingly, the term "teachers at SMAN 1 Batu" is used consistently throughout this study to describe the participants. Exclusion criteria included: 1) Teachers who did not attend the training sessions; and 2) Teachers who did not complete the instruments. The collected data were analyzed using SPSS Windows version 25 with a significance level of α = 0.05 and a 95% confidence level. Data normality was tested using the Shapiro-Wilk test, and the analysis continued using the Wilcoxon test.

RESULTS AND DISCUSSION

Characteristics		Total (f) N = 30	Percentage (%)
Age			
a.	25–34 years	8	26.7
b.	35–44 years	12	40
c.	>45 years	10	33.3
Gender			
a.	Male	7	23.3
b.	Female	23	76.7
Educational Level			
a.	Diploma (D3)	2	6,6
b.	Bachelor's Degree (S1)	23	76.7
c.	Master's Degree (S2)	5	16,7
Teaching Experience			
a.	1–5 years	6	20
b.	6–10 years	6	20
c.	>10 years	18	60

Based on the analysis results, the majority of respondents were aged 35–44 years (40%), followed by those aged >45 years (33.3%) and 25–34 years (26.7%). In terms of gender, most respondents were female (76.7%), while males accounted for 23.3%. Regarding educational level, the majority held a bachelor's degree (76.7%), followed by a master's degree (16.7%) and a diploma (6.7%). In terms of teaching experience, most respondents had more than 10 years of experience (60%), while 20% had 1–5 years and another 20% had 6–10 years of experience.

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Characteristics	Pre-test		Post-test	
	Total (f) N = 30	Percentage (%)	Total (f) N = 30	Percentage (%)
Prior AI/Educational Technology training experience				
a. No	22	73.3	0	0
b. Yes	8	26.7	30	100
Level of capability in using AI/Educational Technology *(*based on self-perception*)				
a. Poor	6	20	0	0
b. Fair	16	53.3	5	16.7
c. Good	7	23.3	19	63.3
d. Excellent	1	3.3	6	20

Before the training, 22 respondents (73.3%) had no prior experience in AI or educational technology training and only 8 people (26.7%) had prior experience. After the training, all respondents (100%) reported having participated in AI-based training. In terms of perceived competency in AI use, before the intervention, the majority of teachers rated their skills as fair (53.3%), followed by good (23.3%), poor (20%), and only 3.3% rated themselves as excellent. After the training, there was a significant increase: the good category increased to 63.3%, very good to 20%, while the poor category was no longer observed. This indicates that the AI training successfully increased teachers' confidence and competence in the use of educational technology.

Uji Wilcoxon	*Self Efficacy*				
	N	Min	Max	Z	Sig.(2-tailed)
Pretest	30	23.00	39.00	-2.833	.005
Posttest	30	29.00	40.00		

The table presents the results of the Wilcoxon signed-rank test comparing teachers' self-efficacy scores before and after the AI training. The pretest scores ranged from 23.00 to 39.00, whereas the posttest scores ranged from 29.00 to 40.00. The test yielded a Z-value of −2.833 and a p-value of 0.005 ($p < 0.05$), indicating a statistically significant difference in teachers' self-efficacy scores before and after the intervention.

Wilcoxon Test	Academic Resilience				
	N	Min	Max	Z	Sig.(2-tailed)
Pretest	30	82.00	140.00	-4.445	0.001
Posttest	30	118.00	150.00		

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The Wilcoxon test results for the teachers' academic resilience showed a pretest score range of 82.00–140.00, whereas the posttest scores ranged from 118.00 to 150.00. The test yielded a Z value of −4.445 and a significance level of $p < 0.001$, indicating a statistically significant difference in academic resilience scores between the pre-training and post-training assessments. These results indicate that AI-based educational interventions not only improve teachers' technical skills, but also enhanced teachers' academic resilience and their ability to cope with the challenges of digital transformation in education.

Wilcoxon Signed Ranks Test		***Self Efficacy***		
		N	Mean Rank	Sum of Rank
Posttest-Pretest	Negative Rank	5a	6.90	34.50
	Positive Rank	16b	12.28	196.50
	Ties	9c		
	Total	30		

The Wilcoxon Signed Ranks Test showed a positive change in Self-Efficacy scores between the pretest and posttest assessments. Among the 30 participants, 16 participants obtained higher scores at posttest than at pretest, while 5 participants showed lower scores and 9 participants demonstrated no change. The positive ranks (Mean Rank = 12.28, Sum of Ranks = 196.50) exceeded the negative ranks (Mean Rank = 6.90, Sum of Ranks = 34.50), indicating that improvements in self-efficacy were more common than declines. These findings suggest that the intervention contributed to an increase in participants' self-efficacy levels, although the magnitude and statistical significance of the change should be interpreted in conjunction with the Wilcoxon test statistics (Z and p-value).

Wilcoxon Signed Ranks Test		**Academic Resilience**		
		N	Mean Rank	Sum of Rank
Posttest-Pretest	Negative Rank	1a	12.00	12.00
	Positive Rank	28b	15.11	423.000
	Ties	1c		
	Total	30		

The Wilcoxon Signed Ranks Test revealed a substantial increase in Academic Resilience scores from pretest to posttest. Among the 30 participants, 28 participants obtained higher scores at posttest than at pretest, whereas only one participant showed a decrease in score, and one participant exhibited no change. The positive ranks (Mean Rank = 15.11, Sum of Ranks = 423.00) greatly exceeded the negative ranks (Mean Rank = 12.00, Sum of Ranks = 12.00), indicating a consistent upward trend in Academic Resilience following the intervention. These findings suggest that the intervention was associated with an improvement in participants' Academic Resilience

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Data Completeness

A total of 30 teachers participated in this study and were included in the data analysis. Data completeness was assessed by examining the availability of pretest and posttest scores for both self-efficacy and academic resilience. All 30 participants completed the pretest and posttest assessments, resulting in a complete dataset for the analysis of both variables. No missing pretest or posttest scores were identified among the participants. Therefore, all 30 participants (100%) were retained for the final statistical analysis using the Wilcoxon Signed-Ranks Test. The complete dataset enabled a paired comparison of participants' scores before and after the AI-based educational intervention.

DISCUSSION

Respondent Demographics

The characteristics of the respondents in this study are presented to provide a general overview of the participants' profiles. Demographic aspects analyzed included gender, age, education level, teaching experience, experience with AI or educational technology training, and self-perceived competency in AI and educational technology. The analysis revealed that the majority of respondents were female (76.7%, n = 23), while the remaining respondents were male (23.3%, n = 7). This finding indicates that female educators comprised a higher proportion than males. This is consistent with a general trend in the primary and secondary education sector in Indonesia, where women predominantly hold teaching positions (Kull, 2019).

In terms of age, the majority of respondents were aged 35–44 years (40%, n = 12), followed by those aged 45–55 years (33.3%, n = 10), and 25–34 years (26.7%, n = 8). This indicates that most respondents were of productive age and fell into the middle-adulthood category, which is generally associated with career stability and considerable professional experience in education.

In terms of educational level, the majority of respondents (76.7%, n = 23) had a Bachelor's degree (S1), followed by 5 respondents (16.7%, n = 5) who had a Master's degree (S2), and 2 respondents (6.7%, n = 2) who had a Diploma (D3). This data indicated that the majority of respondents had completed higher education and possessed sufficient academic competencies to understand the concepts and application of educational technology in the learning process.

In terms of teaching experience, the majority of respondents (60%, n = 18) had more than 10 years of teaching experience, while 20% (n = 6) had 6–10 years of experience and the remaining 20% (n = 6) had 1–5 years of experience.

Furthermore, 6 respondents (20%, n = 6) had 1–5 years of teaching experience, and another 6 respondents (20%, n = 6) had more than 10 years of teaching experience. This distribution indicated that most respondents had considerable teaching experience, thus suggesting that they had the ability to adapt and apply various learning methods. Research in educational technology indicates that teaching experience can serve as a moderator in technology adoption, but other factors such as digital skills, pedagogical knowledge, and institutional facilitation conditions are often more determinant (Mafa and Govender, 2025).

Based on the results of identifying previous training experiences in AI or educational technology, it was found that most respondents had never attended training (73.3%, n = 22), while only 8 respondents (26.7%, n = 8) reported having training experience in this field. This finding indicated limited access to training

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and professional development activities related to the application of artificial intelligence in education. These findings suggest that capacity building through training remains a critical need for educators.

Meanwhile, analysis of the level of ability to use AI or educational technology based on self-perceptions showed that the majority of respondents rated themselves as having adequate ability (53.3%, n = 16), followed by good ability (23.3%, n = 7), poor ability (20%, n = 6), and very good ability (3.3%, n = 1). These results indicate that respondents' ability to utilize educational technology remains at a moderate level. Research indicates that ICT training, access to technology, and institutional support are important predictors of teachers' digital competence and their self-perceptions of these skills (Ikhlas and Dela Rosa, 2023). Therefore, ongoing efforts in the form of training, mentoring, and improving digital literacy are needed to further develop these skills optimally.

Artificial Intelligence as an Educational Intervention to Enhance the Academic Resilience of STEM Teachers in SMAN 1 Batu

The results of the analysis using the Wilcoxon Signed-Ranks Test indicated a significant difference between pretest and posttest scores, with a Z value of −4.445 and a significance level of $p < 0.001$.

This finding suggests that the AI-based educational intervention led to a statistically significant improvement in the academic resilience of STEM teachers at SMAN 1 Batu. These results demonstrate that the integration of Artificial Intelligence (AI) in educational practices not only impacts teachers' cognitive and technopedagogical aspects but also enhances psychological dimensions, including their ability to adapt, persist, and recover when facing academic challenges and digital transformation.

The increase in posttest scores further indicates that AI-based interventions can strengthen teachers' academic resilience, defined as the ability to adapt positively to pressures and changes within their professional context. Previous research has shown that the implementation of AI-based technologies can enhance teachers' self-efficacy and cognitive flexibility through adaptive learning experiences that stimulate problem-solving skills and professional reflection. This finding is consistent with the context of this study at SMAN 1 Batu, where the use of AI as an educational intervention supported STEM teachers in adapting to curriculum changes and digital teaching practices (Zawacki-Richter et al., 2019).

In addition, research indicates that AI has significant potential to support the development of teachers' socio-emotional competencies and resilience through adaptive feedback-based learning. AI-based approaches enable teachers to gain reflective experiences and engage in personalized learning, which can enhance psychological resilience and their ability to cope with work-related stress in the digital era. The findings of this study are consistent with previous studies showing an increase in academic resilience after teachers received direct exposure to AI-based interventions (Wang et al., 2024). Furthermore, Mieres-Chacaltana et al. (2025) highlighted that the integration of digital technologies and AI in education can strengthen digital resilience, defined as teachers' capacity to navigate technological changes with a positive and confident attitude. In the context of STEM teachers at SMAN 1 Batu, this improvement is reflected in the increase in posttest scores following the intervention, indicating enhanced adaptive capacity and confidence in using educational technologies.

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The significant improvement identified through the Wilcoxon test further supports the view that AI-based training and interventions play an important role in strengthening teachers' academic resilience through increased digital self-efficacy. Yuan et al. (2024) explained that teachers with high self-efficacy in using AI are better able to manage work-related stress and technological changes, as they feel more confident integrating AI into their teaching practices. Therefore, the positive effects observed in this study can be interpreted as resulting from increased teacher self-efficacy following direct exposure to AI as a tool for learning and professional reflection. These findings are also consistent with Shezad et al. (2025), who concluded that AI-based training can enhance teachers' adaptability to changes in the educational environment, expand cognitive flexibility, and foster reflective attitudes, which are key components of academic resilience. Thus, the AI-based educational intervention implemented among STEM teachers at SMAN 1 Batu can be considered an innovative strategy for strengthening academic resilience and readiness to face digital transformation in education.

Conceptually, the increase in academic resilience achieved through AI-based interventions can be explained by transformative learning theory proposed by Mezirow (1997), which posits that challenging learning experiences, such as the integration of AI, can lead to shifts in individuals' perspectives, enabling them to become more reflective, critical, and adaptive to new situations. In the context of STEM teachers, the use of AI not only enhances technological knowledge but also fosters a more flexible and resilient mindset in response to the dynamics of 21st-century learning. The results of the analysis, which show a significant increase between pretest and posttest scores, indicate that the AI intervention had a significant impact on improving teachers' academic resilience. This improvement reflects the effectiveness of AI-based learning strategies in facilitating reflective, collaborative, and contextual learning experiences. This finding is also aligned with national education policies that emphasize the importance of strengthening teachers' adaptive competencies in relation to digital technology and artificial intelligence (Kemdikbud Ristek, 2023).

Artificial Intelligence as an Educational Intervention to Enhance the Self-Efficacy of STEM Teachers at SMAN 1 Batu

The results of the analysis using the Wilcoxon Signed Ranks Test indicate a significant difference between the self-efficacy scores of STEM teachers before and after receiving an AI-based educational intervention ($Z = -2.833$, $p = 0.005$). These findings indicate that training programs utilizing AI technology have a positive impact on improving teachers' self-efficacy in implementing STEM-based learning.

This improvement can be explained by the mechanisms through which AI functions as a reflective and adaptive tool in the learning process. AI provides instant feedback, interactive learning simulations, and data-driven recommendations for teaching strategies. These features enable teachers to better understand their strengths and limitations in implementing STEM approaches, thereby fostering improvements in self-efficacy (Bandura, 1997). With increased self-efficacy, teachers become more innovative and confident in integrating science, technology, engineering, and mathematics in the classroom.

In addition, the use of AI contributes to the enhancement of teachers' academic resilience. This technology enables teachers to address educational challenges using solution-oriented approaches, such as analyzing learning problems through predictive algorithms or adaptive learning systems. This finding

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is consistent with Nugroho et al. (2023), who suggest that the use of digital technology in teacher professional development can strengthen adaptive capacity and emotional resilience in response to work-related pressures.

The rank data show that 16 respondents exhibited increased scores (positive ranks) with a mean rank of 12.28, while only 5 respondents showed decreased scores (negative ranks). This indicates that the majority of teachers experienced improvements in self-efficacy following the intervention. Additionally, 9 respondents had tied scores, suggesting that some teachers maintained stable levels of self-efficacy, possibly due to individual factors such as teaching experience or independent learning habits.

From a theoretical perspective, these findings support Bandura's (1997) theory of self-efficacy, which posits that mastery experiences, verbal persuasion, and psychological conditions contribute to the development of self-efficacy. In this study, teachers' success in understanding and implementing AI-based learning serves as a form of mastery experience that strengthens their self-efficacy.

This study also reinforces findings from Putri et al. (2022), which suggest that digital learning environments can enhance teachers' self-efficacy and academic resilience in responding to curriculum changes. Therefore, the application of AI as an educational intervention is effective not only in improving teachers' technological competence but also in strengthening psychological aspects such as self-efficacy and academic resilience.

Study Limitations

This study has several limitations. First, the pre-experimental one-group pretest–posttest design did not include a control group, limiting the ability to attribute the observed changes in teachers' self-efficacy and academic resilience solely to the AI-based educational intervention. Other factors, such as participants' prior experiences, external influences, and familiarity with the assessment instruments, may have contributed to the observed changes. Second, the study involved only 30 teachers from a single senior high school, which limits the generalizability of the findings to teachers in other schools or educational contexts. Third, the absence of a comparison group and long-term follow-up assessment limits conclusions regarding the sustained effects of the intervention. Future studies should consider larger and more diverse samples, controlled research designs, and follow-up assessments to evaluate the effectiveness and durability of AI-based educational interventions.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study demonstrates that AI-based educational interventions are effective in enhancing the academic resilience and the self-efficacy of STEM teachers at SMAN 1 Batu. The results of the Wilcoxon Signed Ranks Test indicate significant differences between pretest and posttest scores in both variables, suggesting that AI-based training has a positive impact not only on technopedagogical aspects but also on teachers' psychological dimensions. The improvement in academic resilience indicates that teachers are better able to adapt, persist, and recover when facing learning challenges and digital transformation. Meanwhile, the increase in self-efficacy reflects a stronger belief in teachers' capabilities to implement STEM-based learning with the support of AI technologies.

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Recommendations

Future research should employ more robust experimental designs, such as quasi-experimental designs or randomized controlled trials, by incorporating control groups to enable more accurate comparisons of intervention effectiveness. In addition, the sample size should be increased to include various educational levels and regions in order to enhance the generalizability of the findings. Further studies are also encouraged to examine the long-term impact of the use of AI on learning performance, teachers' psychological well-being, and the integration of technology in everyday pedagogical practices. Moreover, the development of sustainable AI-based training models tailored to teachers' needs should be further investigated to ensure the sustained improvement of competencies and educators' academic resilience.

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