

Do Differences Matter? A Comparative Study of AI Integration Readiness Among Pre-Service Teachers Across Disciplines and Genders

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☞ The rapid advancement of artificial intelligence (AI) technologies is reshaping the future of education and redefining the competencies required of teachers. As part of national reforms in Indonesia's teacher education system, the *Pendidikan Profesi Guru* (PPG) program has integrated digital training aimed at enhancing pre-service teachers' readiness to adopt emerging technologies, including AI. This study investigates whether pre-service teachers' readiness to integrate AI, measured through the Technological Pedagogical Content Knowledge (TPACK) framework, and self-assessment of self-efficacy and AI readiness, varies significantly based on gender and disciplinary background. Quantitative data were collected from 200 pre-service teachers through an online Likert-scale questionnaire comprising 52 validated items. The constructs measured included TPACK, AI-related self-efficacy, and AI readiness. Data were analysed using independent samples t-tests to examine gender-based differences and one-way ANOVA followed by Tukey HSD post-hoc tests to analyse differences across five disciplinary categories: Natural Sciences, Social Sciences, Mathematics, Primary Education, and Language Education. The results indicated no significant differences in AI readiness, self-efficacy, or TPACK across gender groups. However, significant differences in self-efficacy emerged across academic disciplines, particularly between participants from Social Sciences and Primary Education backgrounds. Boxplot visualisations further highlighted disparities in score distributions, suggesting uneven levels of confidence within specific subject groups. The findings underscore the need for discipline-sensitive strategies in AI-related teacher education. While gender parity appears to have been achieved in digital readiness,

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differentiated pedagogical interventions are essential to address discipline-specific gaps in self-efficacy and ensure equitable integration of AI across educational contexts.

Keywords: AI readiness, self-efficacy, teacher education, TPACK

Ali so razlike pomembne? Primerjalna študija pripravljenosti na vključevanje umetne inteligence med bodočimi učitelji različnih predmetnih področij in spolov

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≈ Hiter napredek tehnologij umetne inteligence (UI) sooblikuje prihodnost izobraževanja in na novo opredeljuje kompetence, ki se zahtevajo od učiteljev. V okviru nacionalnih reform indonezijskega sistema izobraževanja učiteljev je bilo v program *Pendidikan Profesi Guru* (PPG) vključeno digitalno usposabljanje, namenjeno izboljšanju pripravljenosti bodočih učiteljev na sprejemanje nastajajočih tehnologij, vključno z UI. Ta študija preučuje, ali se pripravljenost bodočih učiteljev na vključevanje UI, merjena s pomočjo okvira tehnološko-pedagoškega znanja o vsebini (TPACK), ter samoocena samoučinkovitosti in pripravljenosti na UI bistveno razlikujeta glede na spol in predmetno področje. Kvantitativni podatki so bili zbrani pri 200 bodočih učiteljih prek spletnega vprašalnika z Likertovo lestvico, ki je vseboval 52 validiranih postavk. Merjeni konstrukti so vključevali: TPACK, samoučinkovitost, povezano z UI, in pripravljenost na UI. Podatki so bili analizirani z uporabo neodvisnih vzorcev t-testov, da bi preučili razlike med spoloma, in enosmerne ANOVA, ki ji je sledil Tukeyjev HSD post-hoc test za analizo razlik med petimi predmetnimi področji: naravoslovje, družboslovje, matematika, vzgoja in izobraževanje v osnovni šoli in jezikovno izobraževanje. Izsledki niso pokazali nobenih pomembnih razlik v pripravljenosti na UI, samoučinkovitosti ali TPACK-u med skupinami po spolu, so se pa med predmetnimi področji pokazale znatne razlike v samoučinkovitosti, zlasti med udeleženci s področja družboslovja ter vzgoje in izobraževanja v osnovni šoli. Prikazi z grafikoni kvartilov so dodatno poudarili razlike v porazdelitvi točk, kar kaže na neenakomerno raven samozavesti znotraj posameznih ciljnih skupin. Ugotovitve poudarjajo potrebo po strategijah, ki upoštevajo posamezna predmetna področja, v izobraževanju učiteljev na področju UI. Čeprav se zdi, da je bila pri digitalni pripravljenosti dosežena enakost med spoloma, so diferencirani pedagoški ukrepi bistveni za odpravo razlik v samoučinkovitosti, značilnih za posamezna področja, in za zagotovitev pravičnega vključevanja

UI v različnih izobraževalnih kontekstih.

Ključne besede: pripravljenost na umetno inteligenco (UI), samoučinkovitost, izobraževanje učiteljev, tehnološko-pedagoško znanje o vsebini (TPACK)

Introduction

The rapid advancement of artificial intelligence (AI) technologies is reshaping education systems across the globe. From automated grading (Leite & Blanco, 2020; Sembey et al., 2024) and personalized learning systems to AI-powered educational platforms (Ren and Wu, 2025), these innovations are transforming not only how students learn but also how teachers design and deliver instruction (Zhou &yes! Hou, 2025). The AI revolution in education is not merely a tool for enhancing teaching efficiency; rather, it brings an immersive impact wherein knowledge is continuously deconstructed and reconstructed through the language of new media (Perla et al., 2024). Consequently, as AI technologies are increasingly integrated into classroom environments, the role of teachers in adapting to and leveraging such technologies becomes more complex and critical (Chiu et al., 2024; Li & Liang, 2025). This is particularly true for future educators – pre-service teachers – who must be adequately prepared not only in pedagogical and content knowledge but also in the technological competencies that will define the classrooms of tomorrow.

One conceptual framework that has gained significant traction in understanding teachers' ability to integrate technology effectively is the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). TPACK refers to a teacher's understanding of how to integrate technology into different instructional strategies based on the subject matter (Alhamid & Mohammad-Salehi, 2024). TPACK extends Shulman's (1986) notion of pedagogical content knowledge by incorporating technology as a third essential domain, emphasising the dynamic interplay between these three areas of knowledge. In the context of AI integration, TPACK becomes even more critical, as it requires teachers to not only understand subject matter and pedagogy but also to navigate the ethical, practical, and design-related considerations of AI tools (Chiu et al., 2024; Ren & Wu, 2025).

However, possessing knowledge alone is insufficient. Equally important is a teacher's belief in their ability to use these tools effectively, commonly referred to as self-efficacy (Bandura, 1997; Lee & Tsai, 2010). Self-efficacy has consistently been shown to influence technology adoption, with higher levels of confidence often translating into greater willingness to engage with and implement new technologies in educational settings. Within the AI context, self-efficacy encompasses not only comfort with using intelligent systems but also a belief in one's ability to critically evaluate and pedagogically align such tools with learning objectives (Asio, 2024).

While several studies have examined TPACK and self-efficacy in the broader context of educational technology integration (Chai et al., 2011; Teo, 2008), the relationship between these constructs and AI readiness among pre-service teachers remains underexplored. The concept of AI readiness in education is still emerging. While there is no universally agreed-upon definition, it generally includes three interrelated components: technical familiarity, pedagogical adaptability, and psychological willingness to engage with AI tools (Holstein et al., 2020). Moreover, limited research has explored how personal and contextual factors – such as gender and disciplinary background – influence pre-service teachers’ preparedness to integrate AI into their future teaching. Gender has historically played a role in technology acceptance, with studies suggesting that male teachers may express higher technological self-efficacy than their female counterparts (Venkatesh & Morris, 2000). However, more recent literature indicates that this gap is narrowing, particularly among digital-native cohorts enrolled in teacher education programs (Teo, 2020).

Similarly, disciplinary background may influence how pre-service teachers engage with AI. Those from science, technology, engineering, and mathematics (STEM) fields may have more exposure to technological tools and may therefore report higher levels of confidence and readiness. In contrast, those in non-STEM fields, such as language or social studies, may perceive AI as less relevant to their teaching practice, potentially resulting in lower self-efficacy or perceived readiness. These patterns highlight the need to explore not just whether pre-service teachers are ready to use AI, but how such readiness may differ across gender and academic disciplinary context.

Indonesia is currently undergoing major reforms in teacher digital competencies through the *Pendidikan Profesi Guru* (PPG) program, a national initiative aimed at preparing pre-service and in-service teachers with the pedagogical, professional, and technological skills necessary for 21st-century learning. As part of these reforms, there is an increasing emphasis on integrating educational technology, including AI, into teacher education curricula. However, questions remain regarding whether these reforms are reaching different groups of pre-service teachers equitably, especially when considering gender and disciplinary diversity.

This study seeks to answer the following research questions:

- a. To what extent do gender differences influence pre-service teachers’ levels of TPACK, self-efficacy, and AI readiness?
- b. Are there significant differences in TPACK, self-efficacy, and AI readiness among pre-service teachers based on their academic disciplinary background (i.e. Natural Sciences, Social Sciences, Primary School Teaching, Mathematics, and Language Education)?

Against this backdrop, the present study aims to investigate the extent to which gender and disciplinary background influence pre-service teachers' AI integration readiness. Using validated instruments to measure TPACK, self-efficacy, and AI readiness, this study compares responses from 200 pre-service teachers enrolled in the national PPG program. Through t-tests and one-way ANOVA, the existence of statistically significant differences among these groups is examined, leading to implications for teacher education programs. By identifying key disparities – or the absence thereof – this study contributes to the growing discourse on equitable teacher preparation in the age of AI. This research is important for assessing the readiness of pre-service teachers to integrate AI into their teaching practices equitably, considering gender and disciplinary backgrounds. As noted in previous studies (e.g. Chilla et al., 2024), digitalisation and inclusion are critical cross-cutting themes in teacher professional development and have been a major focus of research. The findings are expected to inform the design of more inclusive, context-sensitive education programs that not only build knowledge and skills but also foster the confidence necessary for meaningful AI integration in diverse classroom settings.

Method

This study employed a quantitative comparative design to examine differences in AI integration readiness among pre-service teachers based on gender and academic disciplinary background. The research focused on three core constructs: Technological Pedagogical Content Knowledge (TPACK), self-efficacy, and AI readiness. The study utilised a cross-sectional survey to capture perceptions and self-assessed competencies at a single point in time, consistent with similar studies in educational technology integration (Teo, 2008; Tondeur et al., 2017).

Participants

The participants were 200 pre-service teachers enrolled in the PPG program in Indonesia during the academic year 2024/2025. The sample was selected using convenience sampling from multiple teacher education institutions. The gender distribution included 155 female and 45 male participants. Participants represented five disciplinary backgrounds, as can be seen in Table 1:

Table 1
Participants' Academic Disciplinary Background

Academic Disciplinary Background	Number of Participants
Natural Sciences	45
Social Sciences	38
Primary School Teachers	50
Mathematics	37
Language	30

This diverse representation ensured sufficient variance to investigate group-based comparisons across both gender and disciplinary background.

Instruments

The data were collected using a structured online questionnaire consisting of 52 items rated on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The instrument was developed based on validated theoretical constructs and adapted to the Indonesian teacher education context. It measured three core dimensions: Technological Pedagogical Content Knowledge (TPACK), self-efficacy, and AI readiness. Prior to deployment, the questionnaire was reviewed by two educational technology experts for content validity and piloted with 20 pre-service teachers to ensure clarity, cultural appropriateness, and internal consistency. This multi-dimensional instrument is consistent with recent approaches to digital teacher competence assessment, as discussed by Paneru (2018) and Chilla et al. (2025), emphasising the importance of integrated frameworks in understanding educators' digital preparedness across contexts.

The TPACK construct, consisting of 24 items adapted from Chai et al. (2011), assessed participants' integrated knowledge of technology, pedagogy, and subject content. The items covered seven subdomains: technological knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), and the overarching TPACK construct. Sample items included: "I can design learning activities that effectively integrate content, pedagogy, and technology," and "I can use appropriate technologies to enhance the understanding of specific concepts in my subject area." The TPACK scale showed a high internal reliability with a Cronbach's alpha of 0.89.

The self-efficacy construct, composed of 12 items adapted from Bandura (1997) and Teo (2008), measured pre-service teachers' confidence in using digital and AI-based technologies in instructional contexts. The scale encompassed operational self-confidence (e.g., using tools and platforms), instructional self-efficacy (e.g., implementing technology in teaching), and problem-solving abilities (e.g., overcoming technical challenges). Sample items included: "I am confident in using AI tools to enhance student learning outcomes," and "I feel capable of troubleshooting basic problems when using digital learning technologies." The self-efficacy scale yielded a Cronbach's alpha of 0.85.

The AI readiness construct, adapted from Ifenthaler & Schumacher (2016) and Holstein et al. (2020), consisted of 16 items measuring participants' preparedness to integrate AI into classroom practice. This construct encompassed three dimensions: cognitive readiness (e.g., understanding the potential and applications of AI), technical readiness (e.g., operating AI tools), and affective readiness (e.g., openness and motivation to use AI). Sample items included: "I am prepared to explore AI tools that support personalised learning," and "I understand how AI applications can be ethically used in education." This construct demonstrated strong reliability, with a Cronbach's alpha of 0.87.

Overall, the final instrument demonstrated high internal consistency across all constructs and was deemed suitable for capturing the perceived competencies and readiness of pre-service teachers across gender and disciplinary groups.

Data Collection and Analysis

The questionnaire was distributed online through institutional learning platforms and messaging groups used by PPG participants. Responses were collected over a two-week period and subsequently exported into R software for statistical analysis. Prior to analysis, the dataset was screened for missing values and outliers to ensure data quality and validity. Descriptive statistics were computed to determine the mean and standard deviation for each variable. In addition, the Shapiro-Wilk test was conducted to assess the normality of data distribution and determine the appropriateness of parametric tests.

To address the research questions, independent samples t-tests were employed to examine gender-based differences in TPACK, self-efficacy, and AI readiness. One-way analysis of variance (ANOVA) was used to assess differences among the five disciplinary groups: Natural Sciences, Social Sciences, Mathematics, Primary Education, and Language Education. When significant differences were detected, Tukey's HSD post-hoc test was conducted to identify

specific group contrasts. To further support statistical interpretation, boxplots were generated for each construct to visualize the distribution of scores across disciplinary categories and to highlight patterns not captured by statistical tests alone.

Results

This section presents the descriptive and inferential statistics used to address the research questions concerning the impact of gender and disciplinary background on pre-service teachers' TPACK, self-efficacy, and AI readiness. The results are organized into descriptive findings, inferential statistical comparisons, and visual representations to provide a comprehensive view of the data.

Descriptive Statistics

Descriptive statistics were calculated separately for male and female participants across the three constructs, as can be seen in Table 2.

Table 2
Descriptive Data

Construct	<i>M</i> (Male)	<i>SD</i> (Male)	<i>M</i> (Female)	<i>SD</i> (Female)
TPACK	4.16	0.36	4.14	0.33
Self-Efficacy	4.09	0.38	4.00	0.42
AI Readiness	4.32	0.35	4.30	0.36

In terms of TPACK scores, male participants reported a slightly higher mean ($M = 4.16$, $SD = 0.36$) compared to their female counterparts ($M = 4.14$, $SD = 0.33$). However, the difference in mean scores was marginal, suggesting a comparable level of perceived technological pedagogical content knowledge across genders. The small standard deviations further indicate that both male and female participants exhibited relatively consistent perceptions of their TPACK competencies.

Similarly, in the self-efficacy construct, male participants demonstrated a higher mean score ($M = 4.09$, $SD = 0.38$) than female participants ($M = 4.00$, $SD = 0.42$). While this difference is slightly more pronounced than that observed for TPACK, the overall means remained high, indicating that both groups felt confident in their abilities to integrate technology effectively

into their teaching practices. The slightly larger standard deviation for females ($SD = 0.42$) suggests greater variability among female participants' self-perceptions compared to males ($SD = 0.38$).

Regarding AI readiness, male participants again showed a marginally higher mean ($M = 4.32$, $SD = 0.35$) compared to female participants ($M = 4.30$, $SD = 0.36$). Both groups scored highly on this construct, reflecting a generally positive outlook toward the integration of artificial intelligence in educational settings. The nearly identical standard deviations for both genders indicate a similar spread of responses, reinforcing the impression of uniformity in AI readiness perceptions among the participants.

Overall, these descriptive findings reveal minimal gender differences across all three constructs, with consistently high mean scores suggesting that pre-service teachers, regardless of gender, feel well-prepared to integrate technology and AI into their future professional practices.

Gender-Based Comparison in TPACK, Self-Efficacy, and AI Readiness Among Pre-Service Teachers

Independent samples t-tests were conducted to determine whether significant differences existed between male and female pre-service teachers in TPACK, self-efficacy, and AI readiness.

Table 3
T-Test Analysis

Construct	<i>t</i>	<i>df</i>	<i>p-value</i>	Interpretation
TPACK	0.201	198	0.841	Not significant
Self-Efficacy	0.853	198	0.397	Not significant
AI Readiness	0.207	198	0.836	Not significant

Independent samples t-tests were conducted to examine potential gender-based differences in pre-service teachers' TPACK, self-efficacy, and AI readiness scores. The results consistently revealed no statistically significant differences between male and female participants across all constructs.

For TPACK, the t-test yielded a *t-value* of 0.201 with 198 degrees of freedom and a *p-value* of 0.841, indicating that the mean difference between male and female participants was not statistically significant. This finding suggests that both genders perceived their technological pedagogical content knowledge at similarly high levels.

Similarly, self-efficacy scores showed no significant gender-based difference, with a *t-value* of 0.853 ($df = 198$) and a *p-value* of 0.397. Despite minor variations observed in the descriptive statistics, these results affirm that male and female participants exhibited comparable levels of confidence in their ability to integrate technology effectively into teaching practices. For AI readiness, the t-test resulted in a *t-value* of 0.207 ($df = 198$) and a *p-value* of 0.836, again demonstrating no significant difference between genders. Both male and female pre-service teachers reported similarly high levels of perceived readiness to engage with AI technologies within educational contexts.

Overall, the gender-based comparisons indicate that technological competence, self-efficacy, and readiness for AI integration are relatively uniform among pre-service teachers, regardless of gender. These findings reinforce the idea that gender disparities in digital competence may be diminishing among newer cohorts of teachers, reflecting broader societal shifts toward greater digital equity.

Subject Group-Based Comparison

A one-way analysis of variance (ANOVA) was conducted to investigate whether significant differences existed in TPACK, self-efficacy, and AI readiness across pre-service teachers from different academic disciplines: Natural Sciences, Social Sciences, Primary Education, Mathematics, and Language Education.

Table 4
ANOVA Result

Construct	<i>F</i>	<i>df</i> (between, within)	<i>p-value</i>	Interpretation
TPACK	1.70	(4, 195)	0.153	Not significant
Self-Efficacy	2.53	(4, 195)	0.0417	Significant
AI Readiness	1.53	(4, 195)	0.195	Not significant

For TPACK, the ANOVA yielded an *F-value* of 1.70 with degrees of freedom (4, 195) and a *p-value* of 0.153. This result indicates that the differences in TPACK scores across the five academic disciplines were not statistically significant. In other words, regardless of disciplinary background, pre-service teachers perceived themselves to possess comparable levels of technological pedagogical content knowledge.

In terms of AI readiness, the analysis similarly showed no statistically significant differences among the subject groups. The ANOVA produced an

F-value of 1.53 ($df = 4, 195$) with a *p-value* of 0.195. This suggests a general uniformity in perceived readiness to integrate AI technologies across the disciplines, reinforcing the notion that optimism toward AI integration may be a more widespread phenomenon among pre-service teachers, rather than discipline-specific.

However, significant disciplinary differences emerged in the construct of self-efficacy. The ANOVA revealed an *F-value* of 2.53 ($df = 4, 195$) and a *p-value* of 0.0417, indicating that the level of confidence pre-service teachers felt about their technological capabilities varied significantly based on their disciplinary background. This suggests that while foundational knowledge (as reflected in TPACK and AI readiness) may be evenly distributed across groups, the confidence to apply technology meaningfully differs depending on the field of study.

These findings highlight the importance of examining not only knowledge acquisition but also the affective and motivational dimensions of technology integration across educational disciplines. They underscore the need for discipline-sensitive interventions to ensure that pre-service teachers across all subject areas develop both the competence and the confidence necessary to effectively integrate emerging technologies such as AI into their instructional practices.

Post-Hoc Analysis (Self-Efficacy)

Following the identification of significant differences in self-efficacy across academic disciplines through one-way ANOVA, a post-hoc analysis using Tukey's Honest Significant Difference (HSD) test was conducted to further explore where these differences occurred.

The post-hoc comparison revealed that no pairwise comparisons between subject groups reached statistical significance at the conventional alpha level after adjustment for multiple comparisons. However, the comparison between Social Sciences and Primary Education approached significance ($p = 0.069$), suggesting a possible emerging disparity in self-efficacy between these two groups.

This near-significant result indicates that pre-service teachers from Social Sciences may feel notably more confident in integrating technology and AI into their pedagogy compared to their counterparts from Primary Education. Although not conclusive, this trend points to an important nuance: self-efficacy toward technology integration appears to be shaped not only by general technological exposure but also by the perceived alignment between technology use and the nature of the discipline.

The proximity of the p-value to the threshold of significance invites further attention. It suggests that while current teacher education programs may generally foster technological competence across fields, certain disciplinary contexts – particularly foundational education settings – may require more targeted support to boost confidence and readiness for AI integration.

These findings reinforce the need for future teacher education programs to adopt a more differentiated and context-sensitive approach, recognizing that teachers of different subject areas may require distinct strategies to cultivate both technological competence and confidence.

Visual Representations

To complement the descriptive and inferential statistical analyses, three boxplots were generated to visualize the distribution of TPACK, self-efficacy, and AI readiness scores across different academic disciplines. These visualizations provide deeper insights into patterns of variance that may not be fully captured by mean comparisons alone.

a. Self-Efficacy by Subject Group

Figure 1

Boxplot of Self-Efficacy Score by Subject Group

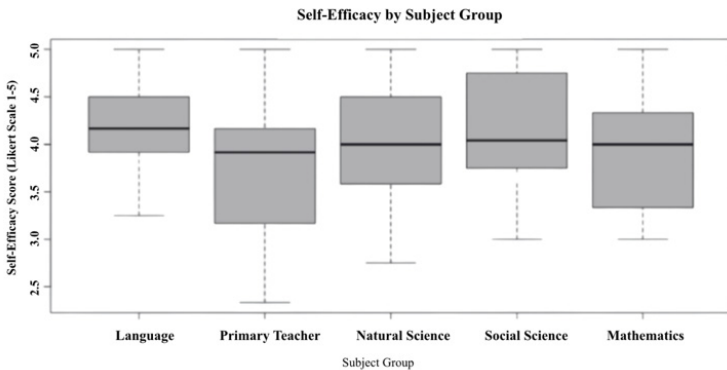


Figure 1 presents the distribution of self-efficacy scores across disciplines. The median self-efficacy scores were highest for Social Sciences (median ≈ 4.2) and Language Education (median ≈ 4.2), indicating strong confidence levels among participants from these fields. In contrast, Primary Education participants reported the lowest median (median ≈ 3.8) and

exhibited the widest interquartile range ($IQR \approx 0.4$), suggesting greater variability and a broader spread of self-efficacy perceptions within this group. The minimum and maximum values for Primary Education ranged from approximately 3.4 to 4.3, while Social Sciences scores clustered tightly between 4.0 and 4.4.

This dispersion highlights potential inequities in digital training experiences, even within a standardized teacher education system. The boxplot visually supports the ANOVA results, emphasizing that although some Primary Education pre-service teachers possess strong self-efficacy, others may feel underprepared, necessitating differentiated support structures.

b. TPACK by Subject Group

Figure 2

Boxplot of TPACK Score by Subject Group

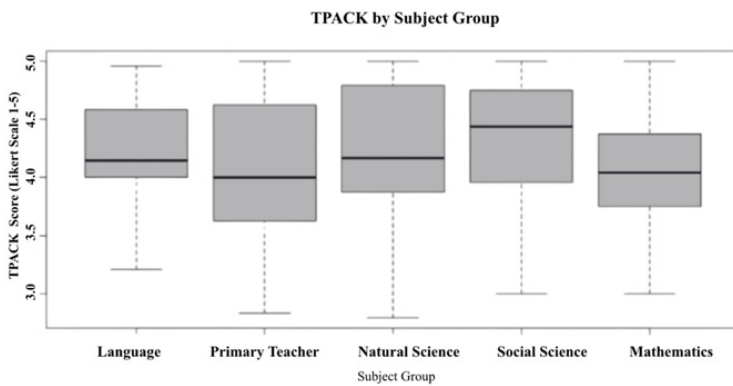


Figure 2 depicts TPACK distributions across the academic disciplines. Median scores for all groups were closely aligned around 4.15 to 4.20, with narrow interquartile ranges (approximately 0.2 across groups), indicating high consistency in perceived technological pedagogical knowledge. The range of TPACK scores across disciplines was relatively narrow (approximately 4.0 to 4.4), with very few outliers. This visual homogeneity mirrors the non-significant ANOVA results and suggests that the PPG program's efforts to standardize technological pedagogical training have been largely successful. Nevertheless, the consistent medians may mask subtle variations in the depth of TPACK understanding or the ability to contextualize technology in diverse subject areas, both of which are critical for meaningful integration.

c. AI Readiness by Subject Group

Figure 3

Boxplot of AI Readiness Score by Subject Group

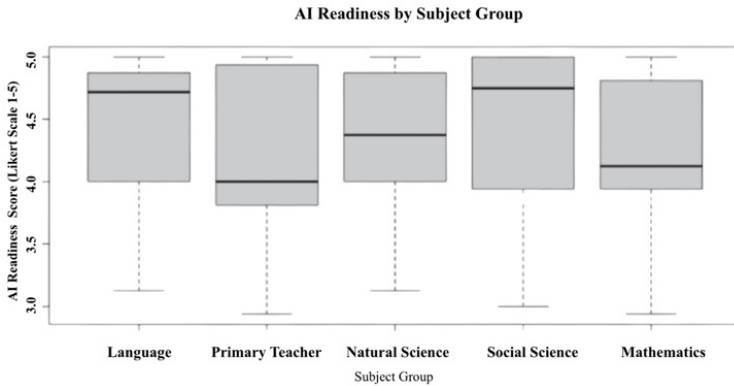


Figure 3 illustrates the distribution of AI readiness scores. Median scores across all disciplines were remarkably high, ranging from approximately 4.25 to 4.40, reflecting strong general optimism toward AI integration. Participants from Social Sciences and Language Education again demonstrated slightly higher median scores (both ≈ 4.4), whereas Primary Education and Mathematics participants showed marginally lower medians (approximately 4.25). The spread of scores was broader for Primary Education, with values ranging from about 3.9 to 4.5. Although no statistically significant disciplinary differences were found, the visualization reveals important nuances: groups like Primary Education not only have slightly lower median AI readiness but also a broader variability.

Discussion

This study explored technological pedagogical content knowledge (TPACK), self-efficacy, and readiness to integrate artificial intelligence (AI) into educational practice among pre-service teachers across academic disciplines and genders. The findings, based on data collected in March 2025 from 200 participants across five academic disciplines, contribute to ongoing discussions regarding equity and preparedness in teacher education during an era of rapid technological change.

Overall, the study revealed no significant gender-based differences across TPACK, self-efficacy, and AI readiness constructs, suggesting a near-parity in

technological competence and confidence among male and female pre-service teachers. However, disciplinary background was found to significantly influence self-efficacy, with Primary Education participants reporting lower confidence levels compared to their peers in Social Sciences and Language Education. These findings offer nuanced insights into how technological readiness is evolving within teacher education and invite reflection on existing assumptions about digital equity and competence.

Gender and Technological Competence

The lack of statistically significant gender differences observed across all three constructs – TPACK, self-efficacy, and AI readiness – is a notable departure from earlier studies. Traditionally, male teachers were reported to have higher technological self-efficacy and a more positive disposition toward technology integration (Sang et al., 2010; Venkatesh & Morris, 2000). This trend was often attributed to greater exposure to technological environments or socio-cultural norms favouring male technological competence.

However, the current findings align more closely with recent research indicating that gender-based gaps are narrowing among younger cohorts, particularly among digital natives (Danyaro et al., 2024; Quiño & Potane, 2023; Teo, 2020; Wong et al., 2021). The integration of technology into everyday life, coupled with inclusive educational reforms, such as Indonesia's PPG program, may have contributed to creating more equitable digital experiences across genders (Howard et al., 2021).

While the convergence in mean scores suggests progress toward gender equity, a critical review of the data warns against complacency. Recent studies, such as those by Chiu et al. (2024) and Hava and Babayiğit (2024), highlight that self-perceived technological competence does not always reflect deeper critical engagement with AI tools. High scores in AI readiness, for instance, may indicate enthusiasm or familiarity with surface-level functionalities but not necessarily a robust understanding of AI ethics, data privacy, or adaptive learning mechanisms – elements crucial for responsible AI integration in education (Holstein et al., 2020).

Thus, while gender parity in self-efficacy and readiness is encouraging, future teacher education programs must ensure that both male and female pre-service teachers move beyond functional readiness toward critical and ethical AI competence (Chen et al., 2025).

Disciplinary Identity and Self-Efficacy in Technology Use

The significant disciplinary differences found in self-efficacy provide a critical insight into how academic specialization continues to shape digital confidence. Pre-service teachers specializing in Social Sciences and Language Education reported higher self-efficacy compared to those from Primary Education, a pattern consistent with the argument that disciplinary cultures influence perceptions and usage of technology (Howard et al., 2021; Tondeur et al., 2017).

Disciplines like Social Sciences and Languages often engage with issues of digital citizenship, media literacy, and communication technologies, where AI tools are visibly relevant (Howard et al., 2021; Ren & Wu, 2025). Consequently, pre-service teachers from these fields may perceive AI as naturally extending their pedagogical toolkit. In contrast, foundational education, with its emphasis on literacy, numeracy, and early childhood development, may lack visible connections to AI applications, resulting in lower perceived relevance and, consequently, lower self-efficacy.

This finding is consistent with previous studies (Luckin & Cukurova, 2019) which suggest that AI integration in early education is often viewed as peripheral rather than essential. Without explicit scaffolding showing how AI can enhance foundational pedagogy – such as adaptive reading interventions or intelligent tutoring systems – Primary Education pre-service teachers may struggle to see AI's value, reinforcing lower confidence.

Critically, the disciplinary effect observed here suggests that technology integration initiatives must be context-sensitive. A standardized curriculum that assumes AI has universal applicability without tailoring examples, tools, and use cases to specific teaching contexts risks alienating certain groups of future educators (Asio, 2024). Therefore, discipline-specific strategies in AI training are not merely desirable but essential for equitable teacher preparation.

Visual Interpretation

The boxplots generated for TPACK, self-efficacy, and AI readiness scores provided further nuance to the statistical findings. The Self-Efficacy boxplot (Figure 1) revealed greater dispersion within the Primary Education group compared to other disciplines. While ANOVA confirmed significant differences in means, the boxplot illustrated that variation within groups can be as important as variation between groups. The wide spread in Primary Education suggests that while some individuals feel confident, a substantial proportion feel considerably less so, pointing to hidden inequities within that disciplinary

group.

The TPACK boxplot (Figure 2) showed tightly clustered distributions across all disciplines, visually affirming the non-significant ANOVA results. This suggests that foundational technological pedagogical knowledge is being delivered relatively uniformly across fields – a success which is potentially attributable to the national curriculum reforms under the PPG framework.

The AI Readiness boxplot (Figure 3), while similarly uniform at first glance, raised a critical point: high median scores (>4.30) across all groups may conceal overconfidence. As Holstein et al. (2020) and Zawacki-Richter et al. (2019) caution, self-reported readiness for AI often exceeds actual critical literacy or pedagogical mastery. Without hands-on experience, ethical training, or critical discussions, pre-service teachers may believe they are ready for AI integration when they are not fully equipped for its complex challenges. Thus, while the statistical and visual analyses affirm encouraging trends, they also signal areas where surface-level perceptions may mask deeper readiness gaps.

Theoretical and Practical Implications

Theoretically, these findings reinforce the idea that technology integration competence is multidimensional, shaped by not only access and training but also by disciplinary identity and contextual relevance (Hava & Babayiğit, 2024; Ifenthaler & Schumacher, 2016). Gender, once a dominant explanatory factor, appears to be diminishing in significance, at least in surface measures of competence, reflecting broader global digital inclusion efforts (Wong et al., 2021).

At a practical level, the results suggest three key strategies to be applied within teacher education:

- a. Maintain and deepen gender-equitable training models, ensuring that high levels of perceived readiness are matched by authentic, critical, and ethical competencies.
- b. Develop discipline-sensitive AI integration frameworks that contextualize AI use within specific pedagogical traditions and goals, making it relevant for all fields – not just STEM or communication-rich disciplines.
- c. Embed critical AI literacy components into teacher education curricula, including hands-on practice, ethical deliberations, and reflective activities that move beyond functional use toward thoughtful, responsible, and context-aware application (Chen et al., 2025; Holstein et al., 2020).

Limitations and Future Research Directions

Despite its contributions, this study has limitations. The use of self-reported surveys may inflate perceptions of competence, especially concerning complex constructs like AI readiness. Future studies could incorporate observational methods, performance-based assessments, or AI simulation-based tasks to triangulate findings. Additionally, the cross-sectional design captures a snapshot in time. Longitudinal studies following pre-service teachers into their professional practice would provide deeper insights into how initial readiness translates into actual classroom AI integration. Future research should also explore institutional and structural factors (e.g., access to AI training, mentorship opportunities, policy support) that mediate gender and disciplinary differences. Investigating these mediators could offer more actionable levers for promoting equitable and effective AI integration in teacher education globally.

Conclusion

This study set out to explore how gender and disciplinary background influence pre-service teachers' readiness to integrate artificial intelligence (AI) into their future teaching. Using validated constructs – TPACK, self-efficacy, and AI readiness – the study analysed responses from 200 pre-service teachers enrolled in Indonesia's *Pendidikan Profesi Guru* (PPG) program.

The results showed that while gender did not significantly affect pre-service teachers' perceived knowledge, confidence, or readiness for AI integration, disciplinary background had a significant effect on self-efficacy, particularly between participants from Primary Education and Social Science backgrounds. These findings suggest that while national teacher education programs may be succeeding in delivering standardized digital knowledge across all groups, confidence and perceived pedagogical relevance of AI still vary depending on disciplinary context.

This distinction matters: self-efficacy is a key predictor of whether teachers will effectively adopt and apply new technologies in their practice. Without targeted support, pre-service teachers in certain disciplines may enter the profession with lower confidence and preparedness to engage meaningfully with AI-enhanced pedagogy.

Therefore, the study underscores the need for teacher education institutions to move beyond a "one-size-fits-all" approach to AI integration. Programs must adopt differentiated instructional strategies that tailor AI training to the pedagogical realities of different teaching fields. Similarly to findings from Uka

et al. (2024), teacher development programs should be designed in a non-uniform manner, focusing on the specific needs of teachers tailored to their respective fields of study. At the same time, policymakers and curriculum developers must continue to strengthen inclusive access and ensure AI readiness is not just a technical skill, but a reflective, ethical, and context-sensitive professional disposition.

As AI technologies continue to shape the future of education, preparing teachers to engage with these tools equitably and effectively will be essential. This study contributes to the growing body of research that informs such preparation, offering empirical insight from a Global South perspective and reinforcing the importance of culturally and disciplinarily responsive teacher education. Future research could explore how these readiness differences evolve over time and how targeted interventions can improve AI confidence in underrepresented disciplines.

Ethical Statement

The research was carried out in accordance with ethical standards for pedagogical research, including informed consent, voluntary participation, and the protection of participants' privacy and data confidentiality. Although Universitas Negeri Yogyakarta does not have a formal Ethical Research Committee, the study received approval from the Head of Curriculum and Educational Technology Department and Dean of Educational Science Faculty, who serves as the responsible authority for research ethics within the institution.

Data Availability Statement

The data supporting the findings of this study are not publicly available due to ethical and confidentiality restrictions related to the protection of the research participants, however, they are available from the corresponding author upon reasonable request.

Disclosure Statement

The authors have no conflict of interest to declare.

When preparing this article, the authors used ChatGPT (OpenAI) on 23 May 2025 for language editing purposes, using the following prompt: "Refine the following excerpt to meet APA standards of academic writing. Remove informal phrasing and ensure the tone is authoritative yet objective. Please fix any

‘dangling modifiers’ and ensure all collective nouns are treated as singular”. The authors subsequently reviewed and edited the output as necessary and accepts full responsibility for the content and integrity of the publication.

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