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Game-Changer or Challenge? An Exploratory Mixed-Method Investigation into AI and Pre-Service Teachers' Efficacy

Abstract

Using a mixed-method approach, this study investigates the potential impact of the introduction of Artificial Intelligence (AI) tools on the self-efficacy beliefs of pre-service teachers. Over a 30-week period of instruction, quantitative data from the Teacher Sense of Efficacy Scale (TSES) revealed a statistically significant increase in participants' sense of self-efficacy. Qualitative data from interviews highlighted benefits such as enhanced instructional confidence, expanded pedagogical repertoires, improved feedback practices, and the fostering of reflective practices. However, there also emerged a number of challenges, including the risk of over-reliance on AI, potentially undermining critical engagement, constraining originality, and creating identity-related tensions. The findings suggest that while the integration of AI tools demonstrates huge potential, teacher education programs must prioritise critical engagement with AI outputs and design-based learning to ensure teachers retain agency and promote responsible AI use in education.

Keywords: pre-service teachers, teacher self-efficacy, teacher training, Artificial Intelligence (AI), ChatGPT

As teachers are widely regarded as the most influential factor in shaping students' learning outcomes (Rowe, 2003), researchers have long sought to understand what makes some teachers more effective than others. Yet, observable teacher characteristics alone have proven insufficient in explaining variations in quality (Jerrim et al., 2023). This has led researchers to focus on psychological constructs, with teacher self-efficacy (TSE) emerging as one of

the most widely examined. Defined as “teachers’ beliefs in their capabilities to bring about desired student outcomes” (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783), TSE has been examined extensively for its significant impact on teacher behaviour, student achievement, and broader school improvement (Jerrim et al., 2023; Künsting et al., 2016). High levels of TSE have been consistently linked to an array of positive outcomes, as teachers with stronger efficacy beliefs tend to be more committed to their work (Demir, 2020), display more confidence in their classroom management abilities (Lazarides, 2020), and foster learning environments that enhance student motivation and achievement (Caprara et al., 2006; Kim & Seo, 2018). Such teachers also typically report higher levels of job satisfaction and engagement, alongside lower levels of stress and burnout (Aldridge & Fraser, 2016; Shoji et al., 2016). Importantly, the foundations of efficacy beliefs are laid during pre-service education, with high-quality preparation programmes consistently linked to reduced stress upon entering the profession and greater preparedness to meet the demands of teaching (Brown et al., 2019; Golubtchik, 2024). Building on this, research has increasingly explored interventions designed to enhance TSE ranging from targeted initiatives in pre- and in-service teacher education (e.g., Chao et al., 2017; Tschannen-Moran & McMaster, 2009) to broader reforms that emphasise sustained practice and professional reflection (Grossman et al., 2009). While such interventions remain crucial for enhancing instructional quality and supporting adaptability, the rollout of artificial intelligence (AI) tools has introduced new possibilities for teacher education. Emerging tools now provide previously unavailable opportunities to automate feedback, simulate classroom interactions, and personalise professional development. Yet, despite the burgeoning presence of AI in education, its influence on pre-service teachers’ beliefs remains largely underexplored. Existing research has focused predominantly on aspects including AI literacy (e.g., Wang et al., 2025), grading and assessment automation (e.g., Jukiewicz, 2024), AI-assisted curriculum design (e.g., Davis & Lee, 2024; Lee et al., 2025b) or engagement with AI-generated feedback (e.g., Zou et al., 2025). An exception is provided by Meegan and Young’s (2025) study, which evaluated a GenAI-supported scenario-based learning intervention in initial teacher education, reporting positive effects on pre-service teachers’ TSE, AI literacy, and teaching confidence. As recent scholarship emphasises the importance of integrating AI into teacher education to foster AI literacy and promote responsible use, there remains a need to investigate how such integration might also shape pre-service teachers’ beliefs. Addressing this gap, the present study examines whether embedding AI into the ELT teacher training curriculum can improve pre-service teachers’ TES over time and how they perceive the opportunities and challenges of engaging with such tools. Accordingly, the study is guided by the following research questions:

RQ1. How does AI-focused preparation affect the pre-service language teachers' efficacy beliefs over time?

RQ2. What challenges and affordances do pre-service language teachers identify in using AI tools to support their professional development?

Literature Review

Teacher Self-Efficacy

Self-efficacy (SE), originating in Bandura's (1997) Social Cognitive theory, is one of the most influential psychological variables in educational research. Defined as individuals' beliefs in their capabilities to organise and execute the actions required to achieve specific goals (Bandura, 1997), SE shapes how people approach challenges, regulate their motivation, and persevere in the face of setbacks. While those with strong efficacy beliefs are inclined to exert sustained effort, persist through obstacles, and ultimately achieve higher levels of performance, individuals with low SE tend to dwell on adversities and display avoidance behaviours (Bandura, 1997). Teacher self-efficacy (TSE) builds directly on this foundation and is typically defined as teachers' judgments of their capacity to bring about desired outcomes of student engagement and learning, even with unmotivated or difficult students (Tschannen-Moran & Woolfolk Hoy, 2001). TSE thus reflects teachers' beliefs in their ability to plan, organise, and implement instructional actions that lead to meaningful educational outcomes. In practice, such beliefs occur across three key areas of teaching: instructional practice, classroom management, and student engagement (Tschannen-Moran et al., 1998). In this sense, TSE provides a lens for explaining why some teachers persist, innovate, and thrive while others struggle when faced with similar challenges. Teachers with stronger efficacy beliefs report greater job satisfaction (Aldridge & Fraser, 2016), higher levels of professional commitment (Demir, 2020), and lower stress and emotional exhaustion (Shoji et al., 2016). Such teachers are also observed to deliver higher-quality instruction (Holzberger et al., 2013), adopt more innovative practices (Neve et al., 2015), and foster more positive classroom climates (Künsting et al., 2016). These advantages extend to students, as higher TSE is associated with greater motivation, engagement, and academic achievement (Caprara et al., 2006; Kim & Seo, 2018).

AI in Teacher Education

Since the rollout of generally accessible AI, its applications have rapidly expanded across a range of fields, including education, where it has been applied to personalise learning, automate grading and assessment, inform curriculum design, and provide supportive feedback (e.g., Davis & Lee, 2024; Jukiewicz, 2024; Lee et al., 2025b; Wang et al., 2025). Research also shows that AI tools shape teachers' emotions, practices, and ethical decision-making (Wang et al., 2025). Despite these advances, questions remain about the pedagogical value of AI and the long-term usage implications. This uncertainty also extends to teacher education. While the need for teachers to develop AI literacy is now widely acknowledged (Wang et al., 2025), the ways in which pre-service teachers engage with AI are only beginning to be systematically explored. Babanoğlu et al. (2025), for instance, found that pre-service EFL teachers regarded AI as a supportive tool, while emphasising the importance of developing ethical, technical, and pedagogical competencies. Other studies have turned to the impact of AI on learning processes and engagement. Fidan and Gencel (2022) showed that integrating chatbots and peer feedback into educational videos enhanced both learning performance and intrinsic motivation, whereas Hwang et al. (2025) reported that pre-service teachers working with chatbots in metaverse classrooms designed more authentic and immersive tasks and expressed more positive perceptions than their peers in traditional settings. In similar vein, Lee et al. (2025a) demonstrated that chatbot-supported tasks in metaverse significantly improved pre-service teachers' Global Englishes awareness, boosting their confidence and intentions to engage in communication. Studies also have argued for equipping future teachers with skills to approach AI critically. Kohnke and Zhou (2025), drawing on the TPACK and SAMR frameworks, emphasised the need to prepare pre-service teachers to address bias, equity, cultural representation, and responsible use in their engagement with AI tools. Finally, several studies have examined how AI can support lesson and curriculum design. For example, in a case study with three pre-service teachers, Davis and Lee (2024) found that ChatGPT was able to generate coherent teaching plans, although it showed limitations in linking prior learning with future learning outcomes. Extending this line of inquiry, Lee and Zhai (2024) demonstrated that pre-service teachers were able to integrate ChatGPT into lesson planning more flexibly, using it to supply content knowledge, scaffold role-playing activities, deliver adaptive instruction, and facilitate feedback and reflection. Similarly, Lee et al. (2025b) explored pre-service teachers' use of gen-AI in lesson design, showing that they exercised agency by collaborating with AI tools while critically addressing their limitations to refine pedagogical outcomes.

Methods

Participants and Sampling

The present study was conducted within a pre-service EFL teacher education programme in Poland and employed convenience case sampling. The cohort consisted of students ($N = 20$) enrolled in an MA-level EFL methodology class taught by one of the authors. Participation was voluntary, with participants providing written consent before completing an online version of the Teacher Sense of Efficacy Scale (Tschannen-Moran & Woolfolk Hoy, 2001). At this point, participants' biodata, including age and gender, was also collected. The sample comprised 14 female and six male students aged 22–24 ($M = 22.75$; $SD = 0.79$). Participants' initial TSE scores ranged from 72.1 to 135.7 ($M = 100.6$; $SD = 17.24$). All participants subsequently took part in a group interview designed to explore the underlying reasons for their relatively low TSE scores and to identify needs that might be addressed through a targeted AI-based training.

AI-Training

To prepare participants for the integration of AI in teaching, a programme was developed that addressed both classroom applications and broader professional competencies. The programme was structured around three core dimensions, all framed within principles of reflective practice: ethical awareness, practical application, and critical reflection. Its design was informed by pre-experiment interviews as well as the ELT methodology course curriculum, ensuring alignment with participants' needs and concerns while also supporting wider professional development objectives. The programme primarily was based on ChatGPT 4.0, Diffit, and Twee. The training was delivered across two sessions per week; one lecture and one practical application workshop. The ethical awareness component focused on responsible AI use, particularly in relation to data privacy, bias, and fairness. Participants engaged in scenario-based discussions in pairs and small groups, analysing situations where AI-generated content could reinforce stereotypes or compromise confidentiality, learning how to evaluate and address risks before implementation. The practical component centred on lesson planning, materials development, differentiated feedback, assessment, content simplification, and instructional support. In collaborative workshops, participants generated tasks and teaching activities with AI, adapted them for delivery, and explored how AI could support both task design and classroom implementation. The critical reflection component encouraged participants to question AI outputs, recognise their limitations, and adapt resources to diverse

learner needs. Reflective practice was fostered through structured forms and guided discussions, prompting participants to consider the pedagogical and ethical conditions under which AI support was most appropriate. Beyond these three dimensions, the programme highlighted additional opportunities for AI integration, including inclusive education, classroom management simulations, and formative assessment.

Importantly, the programme did not aim to develop AI competence as an end in itself. Rather, AI was introduced as a tool to support the development and enactment of core teaching practices. Participants used AI to design and sequence instructional activities, generate and adapt materials, provide differentiated feedback, and offer alternative explanations or content adjustments for diverse learners. In this way, AI functioned as a pedagogical scaffold through which pre-service teachers could strengthen their confidence in planning, delivering, and managing instruction. These practices align with the three dimensions of the Teacher Sense of Efficacy Scale (TSES) and provide a basis for understanding potential changes in self-efficacy. Specifically, the use of AI for lesson planning, material adaptation, feedback, and assessment relates to instructional confidence, as these activities involve selecting, implementing, and adapting instructional approaches (e.g., tailoring explanations, varying task types, and adjusting instruction to learners' needs). Activities involving task design, personalisation, and differentiation further support student engagement by fostering motivation, participation, and responsiveness. The structuring of AI-supported activities and classroom simulations also relates to classroom management, particularly in establishing routines, maintaining productive learning environments, and responding to classroom challenges. By engaging participants in guided, hands-on use of AI across these areas, the programme created opportunities to rehearse core teaching practices in a supported environment. This combination of practice, reflection, and collaborative discussion was intended to reduce uncertainty and strengthen participants' confidence in their ability to implement these practices in real classroom contexts. Ethical awareness and critical reflection informed the use of AI across all three domains by supporting responsible pedagogical decision-making. While the training did not directly target self-efficacy, it was designed to support its development by enabling participants to enact and reflect on teaching practices reflected in the TSES domains.

Data Collection

This study was initiated in the winter semester of 2023/2024, with data collected across consecutive semesters. Consistent with the exploratory orientation of the study, data was collected through multiple research instruments.

Instruments

Teacher Sense of Efficacy Scale

Teacher Sense of Efficacy Scale (TSES) developed by Tschannen-Moran and Woolfolk Hoy (2001) is a widely used self-report instrument designed to capture teachers' perceptions of their self-efficacy. The scale comprises 24 items representing three correlated dimensions: instructional strategies, classroom management, and student engagement. Responses are provided on a nine-point Likert scale (1 = *nothing*, 9 = *a great deal*), with higher scores reflecting stronger self-efficacy beliefs. Across studies, the TSES has shown strong internal consistency, with Cronbach's alpha values frequently exceeding .90. Although the TSES was not designed for technology-specific contexts, it is appropriate in this study as the focus is not on AI competence, but on pre-service teachers' perceived capability to enact effective teaching practices when supported by AI. AI is conceptualised as a pedagogical tool supporting lesson design, engagement, feedback, and classroom processes. The scale therefore enables examination of whether AI-supported training leads to increased confidence in core domains of teaching practice.

In the present study, participants completed the same TSES items on a weekly basis throughout the data collection period using an online survey platform. Weekly measurement was selected to capture change over time with sufficient temporal resolution, consistent with approaches to time-based data collection that rely on equally spaced observations to analyse trajectories of change (Bacon-Shone, 2020). Longitudinal research is specifically concerned with modelling change through repeated observations (Singer & Willet, 2003), and increasing the number of measurement occasions typically enhances the ability to detect such change. At the same time, the design was mindful of potential challenges associated with repeated measurement, including response fatigue and reactivity. To mitigate these risks, several protective measures were implemented, including the use of a validated and reliable instrument, a brief questionnaire format, flexible response timing within each week, and limited reminder procedures. The research team also maintained regular contact with participants and remained available to provide support when needed. These measures were intended to maintain data quality, as increasing the number of observations alone does not compensate for poor measurement quality (Bacon-Shone, 2020).

Semi-Structured Interviews

In-depth semi-structured interviews were conducted either in person or online with all participants at three points during each semester: at the beginning, in the middle, and at the end, resulting in a total of three interviews per participant. While a set of guiding questions was used, focusing primarily on factors underlying shifts in participants' TSE and their reflections on the AI training, the interviews remained flexible to allow participants to expand on personally meaningful experiences. Participants' personal diaries were used as prompts during the interviews to facilitate recall and deepen reflection, with participants invited to elaborate on specific observations or comments. All interviews were audio-recorded, transcribed verbatim, and subjected to member-checking to ensure accuracy. In recognition of the potentially sensitive nature of these discussions, the interview protocol included gentle probing questions, and participants were free to decline answering any questions they found intrusive or overly personal.

Data Analysis

To evaluate whether the observed measurements followed a systematic trend across time, Page's test for trend was used. This non-parametric procedure is particularly suited for repeated-measures designs in which a monotonic increase or decrease is hypothesised, and it does not require the assumptions of normality that underline parametric alternatives such as repeated-measures ANOVA. The method involves ranking observations within each individual, assigning weights according to their temporal order, and aggregating these to compute the L statistic, which reflects the degree of concordance with the hypothesised trend. The test statistic was subsequently standardised to a Z value, allowing significance to be assessed against the null hypothesis of no ordered trend. All analyses were conducted at a significance threshold of $\alpha = .05$. In addition to significance testing, effect size was calculated, yielding $r = .45$, which reflects a large effect according to Cohen's (1988) benchmarks. The use of all 30 measurement occasions in the analysis was intentional, as Page's test is specifically designed to assess ordered trends across repeated observations, and retaining the full sequence of time points preserves the temporal granularity of the data. Consistent with longitudinal approaches that emphasise modelling trajectories of change rather than comparisons between aggregated snapshots (Singer & Willet, 2003), this approach allows for a more precise characterisation of progression over time.

Qualitative data, comprising interview transcripts and personal diaries, were analysed using Braun and Clarke's (2006) inductive thematic analysis.

This approach, emphasising data-driven theme development, was deemed particularly suitable given the exploratory aims of the study (Nowell et al., 2017). Analysis proceeded through multiple readings to establish familiarity with participants’ accounts, followed by line-by-line coding. Initial codes were then iteratively refined and clustered into subthemes, and subsequently into broader themes to reduce ambiguity and thematic overlap. Themes were then reviewed to ensure they reflected recurring patterns in the data, and illustrative quotations were selected for the final report. Table 1 illustrates the progression from initial codes to subthemes and final themes.

Table 1
Sample Systematic Coding

Excerpt	Code	Subtheme	Theme
"It felt great to have a reliable backup if my own ideas fell short" (P1)	AI as reassurance	Perceived instructional safety	AI as a scaffold for instructional confidence
"Having different versions of tasks gave me the confidence that I could walk into the classroom prepared for whoever was sitting in front of me" (P20)	Preparedness for learner diversity	Adaptive lesson planning	AI as a scaffold for instructional confidence

To enhance credibility, follow-up meetings with participants were conducted to solicit feedback and refine interpretations. In addition, coding was independently undertaken by both authors, with minor discrepancies resolved through discussion prior to finalising the analysis.

Findings

Quantitative Findings

Descriptive statistics across the two semesters (Table 2) showed a steady increase in participants’ TSES scores, with the mean score rising from 100.61 in Week 1 to 127.21 in Week 30. The medians followed a similar pattern; while minimum and maximum values suggest that variability persisted across weeks, the overall distribution of scores shifted upward over time.

Table 2
Descriptive Statistics of TSES Scores across 30 Weeks

Week	N	Mean	SD	Median	Min	Max	Sum of Ranks	Mean Rank
W1	20	100.61	17.72	100.00	72.10	135.70	181.00	9.05
W2	20	103.40	16.44	103.90	72.30	140.00	202.00	10.10
W3	20	104.21	17.88	105.30	68.20	135.80	221.00	11.05
W4	20	104.60	17.50	102.25	77.20	128.50	227.50	11.38
W5	20	106.11	14.65	103.65	80.10	137.20	209.00	10.45
W6	20	105.79	16.17	104.30	78.60	140.80	219.50	10.98
W7	20	107.41	15.61	108.70	77.70	137.20	238.00	11.90
W8	20	107.80	15.69	107.40	77.40	148.30	232.50	11.63
W9	20	108.40	16.09	110.55	52.40	126.90	264.00	13.20
W10	20	108.21	15.74	114.20	77.10	128.60	257.50	12.88
W11	20	108.29	15.42	107.70	80.50	133.30	245.50	12.28
W12	20	109.10	14.68	110.15	73.10	138.70	252.50	12.63
W13	20	108.70	15.07	105.60	81.50	139.20	240.00	12.00
W14	20	111.30	14.84	111.00	67.40	132.60	284.50	14.23
W15	20	112.81	14.38	114.55	82.90	137.20	295.50	14.78
W16	20	115.31	14.18	115.05	81.00	143.70	311.00	15.55
W17	20	114.70	15.25	115.35	87.30	149.90	318.50	15.93
W18	20	116.10	14.47	116.50	90.60	143.90	330.00	16.50
W19	20	116.70	12.64	116.35	96.40	140.20	329.00	16.45
W20	20	118.40	13.34	117.45	92.20	145.00	351.00	17.55
W21	20	118.91	13.18	116.30	98.50	146.50	356.50	17.83
W22	20	121.21	13.25	118.95	96.60	141.10	388.00	19.40
W23	20	121.50	13.08	122.85	93.60	144.20	401.00	20.05
W24	20	122.10	12.44	125.75	97.30	141.10	412.00	20.60
W25	20	121.70	14.09	123.90	96.50	144.60	396.00	19.80
W26	20	123.60	12.63	123.85	104.90	156.10	417.00	20.85
W27	20	125.10	13.10	126.60	95.70	151.60	436.50	21.83
W28	20	122.91	13.86	127.85	91.90	140.50	407.50	20.38
W29	20	124.80	13.32	121.95	105.10	146.50	423.50	21.18
W30	20	127.21	12.49	123.65	105.40	151.50	452.50	22.63

These descriptive patterns are visualised in Figure 1, which presents the mean TSES scores with 95% confidence intervals and standard deviations. The figure shows a clear upward trajectory across the 30 weeks, with relatively stable variability.

Figure 1
Mean TSES Scores

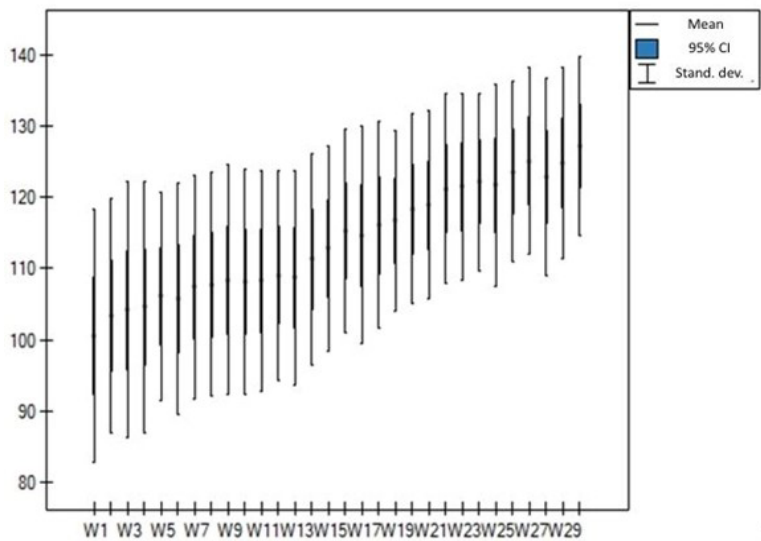
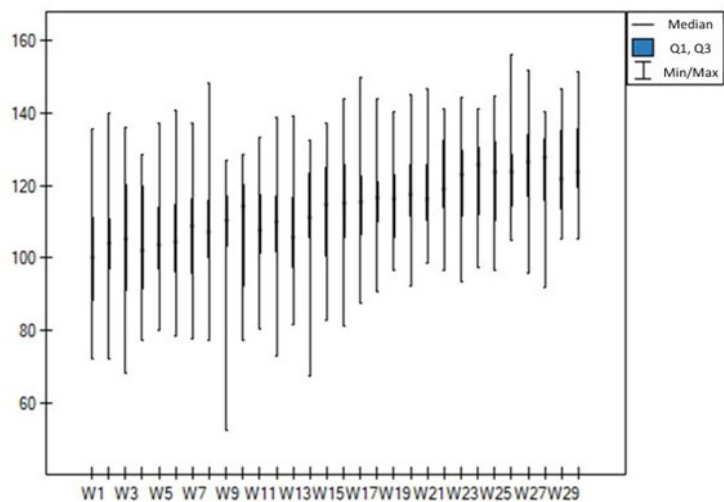


Figure 2 shows the median TSES scores together with interquartile ranges and minimum/maximum values, indicating that the upward trend was evident not only in the means but also across the broader distribution of scores.

Figure 2
Median TSES Scores



To formally test the presence of this progression, Page’s test for trend was conducted. As shown in Table 3, the analysis produced a test statistic of $L = 164,792$, with a standardised value of $Z = 11.06$. Both the one-tailed and two-tailed p -values were below .000001, providing strong evidence for a systematic and significant upward trend. The associated effect size was $r = .45$, which, according to Cohen’s (1988) benchmarks, represents a large effect.

Table 3
Results of Page’s Test for Trend

Statistic	Value
Significance level (α)	0.05
Test statistic L	164,792
Standardised statistic Z	11.06
One-tailed p -value	< 0.000001
Two-tailed p -value	< 0.000001

Qualitative Findings

Affordances Created by AI

Across the interviews, participants highlighted an array of affordances that AI integration brought into their teacher training, often described in terms of how the tools supported the development of TSE by providing reassurance, enabling experimentation, and supporting professional judgement. These affordances align closely with the core domains of the TSES, particularly confidence in instructional strategies, classroom management, and student engagement, thereby providing a qualitative account of the mechanisms underlying the steady increase observed in the quantitative data, with participants’ accounts illustrating how AI-supported practice contributed to the development of self-efficacy over time. One recurring benefit was the development of instructional confidence, which participants interpreted as crucial for exercising their agency more freely. Specifically, AI was often seen as a support that helped participants feel more prepared and secure in their teaching choices. For P1,¹ confidence stemmed from the way AI introduced lesson scenarios he might not have considered on his own. This not only encouraged him to experiment more freely but also provided a sense of reassurance, as he noted it felt “great to have a reliable backup if [his] own

¹ Throughout this section, P is used to denote Participant (e.g., P1 corresponds to Participant 1).

ideas fell short.” A similar experience was described by P7, who observed that the ease of brainstorming ideas and generating alternatives gave him the confidence to employ instructional choices he “would not normally risk.” For P20, instructional confidence was closely tied to inclusivity, as she emphasised how AI supported her in preparing ideas tailored to diverse learner needs. As she explained, having different versions of tasks and alternative approaches “gave [her] the sense that [she] could walk into class prepared for whoever was sitting in front of [her].” Importantly, this growing confidence frequently translated into a greater willingness to move beyond routine practices, with participants framing experimentation as an extension of their agency. This pattern reflects increasing self-efficacy in instructional strategies, as participants demonstrated greater readiness to implement varied and student-centred approaches, which is consistent with the progressive increase in TSES scores observed across the study period. For example, P9 reflected that the training made her realise how much she had been relying on the same resources, acknowledging that “there is more to teaching than standard comprehension tasks and gap-filling exercises.” The ease of designing role-plays, debates, and project-based tasks encouraged the participant to try activities she might not otherwise have considered, which, in turn, led to feelings of “increased teaching competence.” Similarly, P3 described how the training gave her “enough safety to step outside [her] comfort zone,” with the opportunity to pre-brainstorm classroom practices and anticipate possible challenges providing her with the courage to implement them. A comparable sense of reassurance was also evident in P13’s account, who explained that anticipating challenges and exploring alternative lesson scenarios gave her “the confidence to take risks and experiment.”

Participants also highlighted feedback practices as an area in which AI acted as a scaffold, supporting them in making evaluative decisions. Specifically, many participants described how AI sharpened their awareness of what learners most needed from evaluative comments and encouraged them to provide more precise and actionable responses to students’ work. This, in turn, indicates increased confidence in managing classroom learning processes and supporting student progress, aligning with TSES domains related to instructional effectiveness and student engagement. P5, for instance, observed a gradual ability to provide students with “more detailed, meaningful feedback,” explaining that AI tools helped her notice aspects of their work she might otherwise have overlooked. P10 described similar improvement, noting that AI helped her “focus on suggesting improvements that students could actually act on.” For P17, this shift was less about detail and more about tone. Having AI-generated examples to work from, she explained, prevented her from falling back on vague remarks and instead encouraged her to phrase feedback in a way that was more personalised and “made sense for students, not just [herself].”

A further affordance lay in the sense of freedom AI created in lesson preparation, which participants linked to regaining control over aspects of teaching they valued. By handling routine aspects of planning and design, the tools reduced the burden of repetitive work and allowed them to concentrate on more creative and engaging elements of teaching, reflecting a shift towards prioritising meaningful pedagogical goals and growing confidence in their teaching practice. P11 noted that when AI “overtook the tedious formatting,” she could focus on designing lessons around student engagement. P19 expressed a similar view, explaining that skilful use of AI “gave [her] back [her] time,” which she then could devote to developing tasks that “felt purposeful and engaging,” leaving her with the sense that she was “making a real difference” in her private lessons. Others described how removing what they saw as repetitive tasks created space to add a personal touch to their lesson preparation. P3 remarked that once “AI managed the basics,” she could “finally concentrate on the parts that make teaching meaningful,” while P9 explained that having ready-made drafts for her exercises made her “more creative, not less,” since it freed her to design tasks that “genuinely mattered for learners” rather than simply “filling up slides to have enough teaching material.” Additionally, participants often linked this sense of creative freedom to their ability to design more inclusive and differentiated lessons, framing such responsiveness as an essential expression of their agency as teachers. This suggests growing confidence in engaging diverse learners and adapting instruction, both central dimensions of TSE. P7 explained that exploring several ways of presenting the same content gave him greater confidence in adjusting tasks, noting that he had “never felt as prepared to meet the needs of weaker students without neglecting the stronger ones.” P20 similarly reflected that the use of AI made her more efficient in “designing lessons for the whole class, not just the average student,” as generating different lesson scenarios encouraged her to anticipate a wider range of learner needs. P13 shared a comparable experience, explaining that AI outputs frequently reminded her to consider “the full spectrum of learners.” P9 also described how AI helped her prepare activities for mixed-proficiency groups, which “challenged advanced learners while still being accessible to those who struggled.” In the same vein, P17 appreciated the ease of adapting reading passages so she could present both simplified and extended versions of the same text, enabling students at different proficiency levels to engage more actively with the content.

Another area of growth was participants’ engagement in reflective practice, with several describing how experimenting with AI outputs encouraged them to reflect more deeply on their teaching choices. This, in turn, points to the development of professional judgment and self-regulatory capacity, both of which are central to the strengthening of self-efficacy. P11, for instance, began questioning her decisions more closely, asking herself why she responded to

students' errors in a particular way or chose one activity over another. P5 shared a similar perspective, noting that conversations with AI pushed her to reflect more carefully on what had worked in her lessons and what had not. For some participants, this reflective stance extended into the development of long-term learning habits, which was of crucial importance for heightening their awareness of the need for continuous adaptation in their professional lives. P16 remarked that the training reminded her she would "need to keep learning throughout [her] career," realising that her desired profession "will always demand openness to new tools, methods, and perspectives." P9, in turn, described the experience as "revitalising" for her own curiosity, explaining that it led to "the excitement to explore possibilities alongside [her] students." Similarly, P19 associated the use of AI with a sense of ongoing challenge, noting that the rapid advancement of the tools "kept [her] on [her] toes" as she learned to use them more effectively, and that she experienced "a sense of pride" when sharing this knowledge with her students. P11 summarise this shift more broadly, observing that "being a teacher now also means being a learner for life," acknowledging that AI integration will inevitably continue to reshape the experiences of both students and educators.

Finally, participants highlighted how their own struggles with AI sharpened their awareness of the challenges their students would likely face, positioning themselves as key figures responsible for preparing learners for AI-mediated learning. P20 explained that she had come to realise her students "already experiment with AI," which deepened her sense of responsibility to prepare them to use it critically and responsibly. P17 expressed a similar concern, noting that if she herself was unsure about when to trust the content, "students will probably face the same issue," which gave rise to a strong sense of responsibility to guide students through such challenges. For P1, the experience carried an explicitly ethical dimension, as he observed that seeing "how easy it is to depend on AI without thinking critically" prompted him to think more carefully about guiding students towards balanced and responsible use of AI. This heightened sense of responsibility reflects the development of professional agency and, alongside growing confidence in pedagogical decision-making, offers further qualitative support for the upward trend observed in TSES scores.

Challenges Posed by AI

While participants generally recognised the positive effects of AI, these benefits were accompanied by notable challenges. At the centre of these concerns was a perceived weakening of agency, as several participants admitted that the convenience of receiving quick answers often interrupted the deliberate reflection fundamental to their professional judgment. This was perhaps most vividly illustrated by P6, who compared his over-reliance on AI to "outsourcing [his] brain," noting that the resulting reduction in cognitive engagement left him

feeling he was “neglecting [his] professional development.” Despite recognising this risk, he described a gradual decline in reflexivity, admitting that “the more [he] relied on the AI, the less [he] paused to reflect on [his] pedagogical choices.” A similar lack of scrutiny was acknowledged by P12, who admitted that although the AI-generated content was not always “convincing enough,” he nevertheless devoted little to no cognitive effort adapting the material. A comparable weakening of reflexivity was also noted by P8, who confessed that the use of AI reduced her otherwise typical inclination to interrogate her practice, leading her to “stop questioning whether [her] practices matched [her] teaching goals.” For some, this pattern of disengagement also unsettled their confidence in exercising professional judgement, further weakening their sense of agency. P14 described how, when AI proposed alternatives that differed from her own ideas, she often found herself doubting her instincts and often “accepted the proposals instead of double-checking the available options.” P7 expressed a similar concern, admitting that while experimenting with AI for feedback, he sometimes wondered if he was “genuinely addressing [his] students’ needs” or simply “going along with what the tools proposed.” The longer-term effects of decline in reflexivity were evident in P2’s account, who, at the end of the project, admitted she had “barely learned anything,” linking this lack of professional growth to “the temptation of passively copying and pasting what the AI produced.” These findings provide an important counterpoint to the quantitative results, suggesting that while self-efficacy increased overall, its development was at times accompanied by tensions and dependent on how critically participants engaged with AI tools.

Creativity was another area where some participants felt constrained. Specifically, several pre-service teachers described how over-reliance on AI gradually narrowed their inventiveness, leaving them with the impression that they were mostly implementing generic content rather than actively experimenting with new ideas to broaden their repertoires. P4, for example, admitted that her attention shifted more towards “refining what the AI produced” than towards “generating new ideas,” raising her concern about whether she was developing her competence as a teacher. P18 similarly explained that he was largely “adding a personal touch to AI content,” which, over time, “destroyed [his] creativity.” For these participants, the concern was not only about diminished originality but also about the risk of losing the sense of ownership usually attached to independent lesson design, something P2 described as “a gap in [her] development.” Additionally, these concerns prompted broader considerations of professional identity, illustrating how overreliance on AI affected participants’ understanding of their role as teachers. P15, for instance, acknowledged that although he appreciated the opportunities AI introduced, he repeatedly questioned what this implied for his role, asking what “unique value [he] offered” to the profession. This

uncertainty was mirrored in P6's account, who questioned whether he was "really becoming a better teacher, or just getting better at using tools." In fact, similar concerns were articulated across several narratives, with participants explicitly worrying that their future roles risked being reduced to "managers of digital tools" (P15) or "reviewers of machine outputs" (P6) rather than "creators of learning experiences" (P8).

Discussion

With regard to RQ1, the quantitative results revealed an upward trend in TSE across the programme. Both means and medians increased steadily, and Pages's test confirmed a systematic and statistically significant progression in participants' TSES scores. While variability across individuals remained, the overall pattern indicates that the AI-assisted preparation supported participants' growing sense of capability. This pattern can be interpreted in relation to the design of the programme, which positioned AI as a support for enacting core teaching practices reflected in the TSES domains. Through guided, hands-on engagement with AI in lesson planning, material adaptation, feedback, and classroom scenarios, participants were able to rehearse instructional strategies, explore ways of fostering student engagement, and develop responses to classroom challenges. These structured opportunities for practice, combined with reflection and collaborative work, likely contributed to a reduction in uncertainty and to the strengthening of participants' confidence in applying these practices. In this sense, the findings suggest that AI functioned as a scaffold that facilitated the development of teacher self-efficacy over time, with qualitative data providing insight into the mechanisms underlying this process. These findings resonate with those of Meegan and Young (2025), who reported that incorporating AI-based interventions into teacher education may strengthen TSE beliefs. This trend is further supported by the qualitative data, in which many participants frequently framed AI as a resource that supported their instructional confidence, expanded their pedagogical repertoire through experimentation and differentiation, improved their ability to provide feedback, and supported their broader professional growth by fostering creativity, cultivating lifelong learning habits, and heightening their sense of responsibility to prepare students for responsible AI use. Collectively, these findings suggest that integrating AI tools into teacher education may not only support the development of TSE beliefs but also broaden how pre-service teachers envision exercising their agency in their future professional roles.

In response to RQ2, participants identified an array of opportunities and challenges that AI integration brought into their teacher training. The findings suggest that AI integration created a range of affordances that not only supported their professional development but also influenced the ways in which they perceived and exercised their agency as developing teachers. A recurring theme was instructional confidence, with AI described as a supportive resource in lesson preparation that both reassured participants and encouraged them to experiment with previously avoided approaches. By generating lesson scenarios and presenting alternative pathways, the tools widened the pedagogical range participants felt able to employ. This reassurance, in turn, strengthened their emerging sense of agency, encouraging the participants to take risks, adapt strategies, and expand their instructional repertoire. This pattern is consistent with the increase observed in TSES scores, particularly in the domains of instructional strategies and student engagement. Additionally, these findings coincide with previous research that positions AI as most effective when it functions as a co-intelligent partner, expanding rather than replacing teachers' decision-making capacity (Keppler et al., 2024; Lee et al., 2025b; Meegan & Young, 2025).

For the majority of participants, feedback was another area where AI was seen as a scaffold that supported the enactment of professional agency. Specifically, participants described how working with AI tools improved their evaluative awareness, helping them to frame comments in more precise, actionable, and student-centred ways. Rather than simply outsourcing these tasks, the participants engaged with AI input as a starting point that helped them to identify gaps, rephrase overly generic remarks, and tailor feedback more closely to individual learner needs. In doing so, they began to experience a stronger sense of control and responsibility in providing feedback, which contributed to their emerging professional agency and increased confidence in supporting student learning. This view of AI as a supportive partner reflects Lee et al.'s (2025b) observation that pre-service teachers tend to approach AI not as a ready-made solution but as a resource whose value lies in how it can be shaped and refined through their own professional judgment. Additionally, it also resonates with Babanoğlu et al.'s (2025) finding that prospective teachers often conceptualise AI as "the third partner" in a reconfigured teacher-AI-student relationship where teachers retain responsibility for design, ethics, and socio-emotional care.

Beyond feedback, participants also credited AI with reducing the burden of routine preparation, which allowed them to devote more attention to the aspects of teaching they found most meaningful, such as designing engaging activities, adding a personal touch, and concentrating on student learning. This "return of time" appeared to give their practice a clearer sense of purpose which, in turn, fostered the development of stronger efficacy beliefs. As participants redirected their energy toward work they valued, they came to view themselves as more

capable and intentional in their pedagogical choices, supporting both their confidence and emerging professional agency. Importantly, this creative freedom often extended into inclusivity, with participants describing how AI enabled them to differentiate tasks for mixed-ability groups, adapt texts for varying proficiency levels, and anticipate a broader spectrum of learner needs. In these accounts, inclusivity was framed as a central expression of teacher agency, as addressing needs of diverse learners rather than defaulting to the “average student” was understood as a core professional responsibility. This finding resonates with previous research that highlights the agentic dimension of teachers’ role in directing AI outputs to meet learner-specific goals (Lee et al., 2025b; Meegan & Young, 2025).

AI was also described as fostering reflective practice which, over time, expanded into a recognition of lifelong learning as a professional necessity. Specifically, participants often framed their experiences with AI as reminders that effective teaching requires ongoing learning, with many expressing an explicit willingness to keep developing their skills to meet the evolving needs of their future students. At the same time, they connected their own struggles with AI to a heightened awareness of the challenges their students might face, particularly in deciding when and how to trust AI outputs. These reflections align with recent arguments that embedding AI literacy in teacher education should move beyond technical training to include the cultivation of adaptive, reflective, and learner-oriented professional identities (Meegan & Young, 2025; Wang et al., 2025). This awareness also reinforced participants’ view of themselves as future guides in supporting learners’ critical and responsible engagement with AI, a perspective that reflects Miao and Holmes’s (2023) call for educators to be equipped to model responsible AI use and foster student agency in technology-mediated contexts.

Alongside these affordances, participants also pointed to challenges that complicated their development and at times weakened their sense of agency, with a decline in reflexivity emerging as one of the primary concerns. Specifically, some participants acknowledged that the speed and convenience of AI at times tempted them to omit the deeper analysis that would normally guide their pedagogical choices. This sometimes weakened confidence in professional judgement, as participants described deferring to AI suggestions even when they doubted their accuracy. Such accounts illustrate how AI, when used uncritically, risked reducing pre-service teachers’ role to passive recipients of machine outputs rather than active decision-makers, aligning with prior concerns that over-reliance on AI risks diminishing critical thinking and problem-solving, both of which are central to teachers’ professional growth (Bastani et al., 2024; Miao & Holmes, 2023). These findings also suggest that although TSES increased overall, its development was mediated by the extent to which participants engaged critically with AI tools. This contrasts with findings reported by Lee et

al. (2025b), where participants reported steering AI outputs iteratively towards their pedagogical aims. While this divergence warrants further investigation, it may tentatively be attributed to differences in prior exposure to AI as well as to broader qualities such as individual reflexivity and agency. Additionally, several participants described a narrowing of inventiveness as they became accustomed to refining AI-generated content rather than producing original ideas. For these participants, the concern was not only diminished originality but also a sense of compromised authenticity and ownership, which they regarded as essential to their development as teachers. This coincides with wider debates cautioning that while AI can serve as a valuable complement, it may inadvertently constrain creativity if not critically mediated (Eden et al., 2024; Meegan & Young, 2025). Finally, participants expressed uncertainty about their professional identity and role in the era of AI, with some participants questioning the unique value they could bring to students' experiences if AI was already capable of generating lessons and providing feedback. For certain participants, this uncertainty raised doubts about whether they were genuinely developing as teachers or merely becoming more adept at using tools, while others feared that their future role might be reduced to reviewing machine outputs instead of creating meaningful learning experiences. Such reflections point to the deeper implications of AI integration in teacher education, highlighting the risk that pre-service teachers' sense of identity and agency may be unsettled when the boundaries between human expertise and machine capabilities become blurred. As Wang et al. (2025) and Lee et al. (2025b) argue, developing AI literacy within teacher education is therefore not only a matter of technical competence but, more importantly, a way of ensuring that AI is approached as a complement to, rather than a replacement for, pedagogical expertise.

Conclusions, Limitations, and Implications

The present study adopted a mixed-method exploratory approach to investigate how AI-focused preparation influenced the longitudinal development of pre-service teachers' efficacy beliefs and to explore the affordances and challenges associated with the use of AI in their professional training. While both the quantitative and qualitative analyses suggest that integrating AI into teacher education can bring important benefits for pre-service teachers, including stronger efficacy beliefs, greater instructional confidence, more precise feedback practices, a heightened commitment to inclusivity, and deeper engagement in reflection, the findings also highlight several challenges. Participants noted

that the convenience of AI sometimes weakened their reflexivity, that habitual reliance on the tools risked constraining creativity and a sense of ownership over their pedagogical choices, and that uncertainties arose around their professional identity and the unique value they contribute as educators.

The findings carry several important implications for the design of teacher education programmes. While participants valued AI as a scaffold for building instructional confidence, experimenting with new approaches, and refining feedback practices, some were more inclined to rely on it in ways that reduced reflexivity, weakened ownership, and risked over-dependence. As the benefits of AI implementation relied heavily on how critically and deliberately participants engaged with the tools, there is a clear need to frame AI in teacher education as a complement to, rather than a substitute for, pedagogical expertise. Teacher education programmes should therefore provide structured opportunities for candidates to engage critically with AI outputs, compare them against their own decisions, and adapt them for classroom use. By doing so, AI can function as a resource that broadens pedagogical possibilities without diminishing teacher agency, while also preparing future educators to cultivate the same critical and responsible stance in their students. Furthermore, the study reinforces the calls to embed AI literacy as a core component of teacher preparation (Miao & Holmes, 2023; Wang et al., 2025). This requires moving beyond technical competence to include ethical, critical, and pedagogical dimensions, equipping future teachers with the ability to evaluate AI outputs, identify biases, and model responsible use for learners. Additionally, as the findings point to diversity in pre-service teachers' prior experiences with AI, their abilities to enact agency in AI-mediated contexts, and their capacities for critical engagement, we join Meegan and Young's (2025) call for scaffolding AI integration in ways that are sensitive to different development stages of teacher training. This could include differentiating instruction, with novice trainees being guided in the critical analysis of AI-generated content, while more reflexive candidates should have space to test and refine AI content in authentic scenarios. Also, the findings highlight the importance of situating AI integration explicitly around teacher agency. While many participants reported gains in confidence and critical engagement, others raised concerns about weakened reflexivity, ownership, and role clarity. Teacher education could address these risks by fostering design-based learning that encourages candidates to experiment with AI while retaining responsibility for final pedagogical decisions. In this way, AI can expand options, but future educators remain responsible for aligning outputs with their pedagogical goals, an approach consistent with "agency as design judgment" postulated by Lee et al. (2025b). Finally, this study points to a forward-looking responsibility in teacher education, that is, preparing teachers not only to use AI effectively themselves but also to guide students in navigating AI-mediated learning environments. Embedding such orientations into teacher education can

strengthen teachers' sense of agency while fostering critical and responsible AI use among students. In this respect, AI training in initial teacher preparation should not be treated as a temporary adjustment to new technologies but as a foundational element of professional development.

Some limitations need to be acknowledged. First, the present study relied on convenience sampling within a relatively small, context-specific cohort, which limits the generalisability of the findings. However, given the preliminary nature of the work, the primary aim was to explore the potential of AI tools in supporting the development of teacher efficacy rather than to produce generalisable results. Consequently, future studies could recruit larger and more diverse samples to verify whether the observed patterns hold across institutional and cultural contexts. Such extensions would not only strengthen the empirical foundations of this line of inquiry but also provide a deeper understanding of how AI integration shapes teacher self-efficacy across varied educational settings. Second, the lack of a control group reduces the extent to which the findings can be attributed specifically to AI integration. While this, again, could be attributed to the preliminary character of the study, the inclusion of the control group could help establish firmer evidence of causality. Third, although the longitudinal design captured developmental patterns in participants' TSE, reliance on repeated self-report measures and interviews raises the possibility of response bias and reactivity over time (e.g., habituation or fatigue). Future research could address these limitations by integrating classroom observations or perspectives from multiple stakeholders (e.g., students or mentor teachers) and by adopting mixed-frequency measurement designs, thereby capturing the pedagogical impact of AI more directly while balancing sensitivity to change with reduced respondent fatigue. Fourth, the present study focused primarily on affordances and challenges as perceived by participants, without systematically tracing the effects of AI use on actual classroom practices. Future work might therefore compare different modes of AI training to examine how specific approaches shape efficacy over time. Finally, extending the scope to include both pre-service and in-service teachers would yield valuable insights into how the affordances and risks of AI are negotiated at different stages of professional development.

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