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Professional Development of Preservice Teachers in Artificial Intelligence (AI): Empirical Evidence from a Theory- and Practice-Based Seminar

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Due to the rapid rise of artificial intelligence (AI), teacher professionalism needs to be rethought. Teachers require a deep understanding of the technical, ethical and pedagogical aspects of AI and how AI changes teaching and learning. This study examines teacher education students' knowledge of AI as well as their attitudes towards its use in schools. It also explores the potential of a university seminar on AI in education to promote a professional approach and build foundational AI competencies among future teachers. To this end, a pre-post mixed-methods design was employed with a sample of 45 teacher education students who attended a seminar on AI during the final phase of their initial teacher training. Qualitative content analysis was applied to analyze to gain insights into individual perspectives on AI, particularly in educational contexts – supplemented by descriptive statistics on self-rating items. The findings indicate positive attitudes towards the use of AI, but reveal limited knowledge, both about the basics of AI and its application in schools. The study demonstrates that a seminar combining theory and practice can effectively develop AI-related competencies and support a critically reflective approach to digital technologies in education. The study therefore contributes to the emerging body of literature on AI in the context of teacher education, addressing a notable gap in this field.

Keywords: teacher education, artificial intelligence, pre-service teachers, theory- and practice-based seminar, mixed-methods approach

INTRODUCTION

The rapid rise of Artificial Intelligence (AI), along with its related opportunities and challenges, has substantial implications for formal education, teaching and learning. Particularly since the release of ChatGPT in November 2022, public and academic discussion of the implications for teaching and learning has noticeably gained momentum (e.g. Aljemely, 2024; Daha & Altelwany, 2025; Li et al., 2024). Future teachers are facing new challenges, discovering new possibilities, and are expected to develop new competencies, skills, and knowledge for professional development

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(UNESCO, 2024). In this context, the present study examines future teachers' perceptions regarding AI in schools and how these change through in-depth engagement with AI-related topics in the context of a post-graduate teacher training course.

Teacher Professionalism in the Age of AI

Teacher professionalism needs to be rethought and discussed in the context of advances in AI. The role of future teachers is changing, raising fundamental questions about teacher agency and the professional use of AI. They therefore need a deeper understanding of the technical, ethical and pedagogical aspects of AI (UNESCO, 2024). In the context of education, AI has diverse facets. First, AI tools can support teachers in their work, for example in lesson planning, grading, learning support, and preparing for parents' meetings etc. AI is used to simplify administrative tasks, improve efficiency by automating tasks such as curriculum design, generating test questions, or evaluating student assignments (Rasul et al., 2023; Younis, 2025), and to improve the system by analyzing data for evidence-based decision-making (Rasul et al., 2023). Second, AI can play a role in supporting student learning, personalizing learning processes, facilitating adaptive learning and supporting personalized and real-time feedback (Rasul et al., 2023; Tan et al., 2025; Younis, 2025) by using conversational AI or AI-driven learning and assessment systems (Tan et al., 2025). More broadly, AI is seen as a resource for fostering inclusive education by increasing accessibility (OECD, 2024). In addition, immersive technologies such as virtual reality and robotics open up new possibilities for the design of learning processes (Tan et al., 2025). Third, AI tools influence students' strategies regarding, for example, homework and thereby impact teachers' work (e.g., Al Darayseh, 2023; V. R. Lee et al., 2024; Tate et al., 2024). Beyond that, AI raises specific social and societal ethical questions and issues regarding integrity, reliability, bias and privacy (Meylani, 2024; Rasul et al., 2023; Song & Ko, 2024; Wang et al., 2024). In terms of promoting equity and inclusion, AI presents both great potential and considerable challenges (OECD, 2024). The availability and use of AI tools also have implications for the development of, and need for, critical thinking skills (Tan et al., 2025), with teachers being important as key levers: what and how teachers teach shapes students' knowledge and attitudes (J. S. Lee, 2019; Hill, 1971). Hence, teachers serve as multipliers for society.

Teachers play an important role in today's digitalized world and "need to be equipped with essential knowledge and skills about artificial intelligence" (Mulvihill & Martin, 2024, p. 2). Higher levels of digital competence are associated with more positive attitudes towards AI (Galindo-Domínguez et al., 2024), and a deep understanding of AI leads to increased use, the ability to detect AI-generated content, to create AI applications and to use AI for problem-solving (Ayanwale et al., 2024). Numerous studies on AI in education strongly recommend the implementation of comprehensive teacher training on digital literacy and the ethical use of AI (e.g., Fassbender, 2024; Kasepalu et al., 2022; G.-G. Lee & Zhai, 2024; Meylani, 2024; OECD, 2024; Rasul et al., 2023; Tan et al., 2025) especially given the current gap in teacher preparedness. Teachers are confronted with the rapid diversification of AI applications and a continuous influx of new technologies, requiring a high level of technical knowledge and adaptability (Tan et al., 2025; Tang et al., 2023).

While AI is a rapidly emerging research topic in education, there is still a research gap concerning AI in the context of teacher education (Sperling et al., 2024). In a research review from 2015 to 2024, Tan et al. (2025) find that studies on AI in education are mostly focused on its use in teaching, with far less attention given to its role in professional development. They further conclude that well-designed professional development programs can positively influence self-efficacy beliefs, teaching skills and AI-related knowledge.

Designing Opportunities for Teacher Education Students to Acquire AI Literacy

Pre-service teacher education programs should include AI concepts and applications in order to raise awareness of AI and familiarize future teachers with practical AI tools (Al Darayseh, 2023). For (future) teachers, challenging, critical, or practical aspects may be particularly relevant in this context. In the present study, we focus on pre-service teachers as "future architects of educational systems" (Ayanwale et al., 2024). We explore teacher education students' perceptions and knowledge of AI in educational contexts and how these change through intensive engagement with AI-related issues in schools during a postgraduate university course. Based on the findings of Aljemely (2024), Meylani (2024) and Tan et al. (2025), we assume that the professional use of AI, along with its possibilities and challenges, can change students' professional understanding of AI in education. The course design builds on two principles: first, the need to cater for participants with diverse levels of knowledge and experience concerning AI in educational contexts; second, active learning. The course elements were therefore designed so that tasks could be completed at varying levels of difficulty, and the integration of existing knowledge was encouraged.

METHOD

As part of an educational science course within the Master's program in teacher education at the Cluster for Teacher Education West in Austria, a seminar (3 ECTS-credits) was held in the winter semester of 2024/25 focused on the topic of "AI and School". Based on the UNESCO AI Competency Framework for Teachers (2024), the seminar was structured around five core aspects of AI competence: (1) a human-centered mindset, (2) the ethics of AI, (3) the foundations and applications of AI, (4) AI pedagogy, and (5) AI for professional development. Each aspect was organized into three progression levels: acquire, deepen, and create. The seminar aimed to help teacher education students progress from a basic understanding of AI to the ability to engage with it critically and productively in educational settings. To this end, the seminar was explicitly designed as a theory- and practice-based learning environment, with theoretical foundations systematically linked to practical, application-oriented activities. The theoretical element comprised structured input sessions on AI concepts, pedagogical frameworks and ethical considerations, all of which were aligned with the UNESCO framework to ensure conceptual clarity and critical perspectives. The practical dimension was realized through project-based learning, collaborative inquiry and authentic tasks that required students to apply their theoretical knowledge into practice. The seminar was divided into six sessions. The first sessions provided a theoretical foundation in AI, connecting it to the students' prior experiences and

interests in AI and education. This initial phase aimed to activate existing knowledge and foster personal relevance. The subsequent sessions involved intensive practical engagement, during which theoretical aspects such as ethics, international perspectives and other key issues introduced earlier were critically reflected upon in relation to school practice. A distinctive feature was that the practice-oriented activities were not isolated exercises, but were always embedded in educational contexts. A central element of the course were student-produced podcasts on topics related to AI in education, chosen by the students themselves. These podcasts were developed throughout the six sessions, providing an ongoing opportunity to connect theoretical insights with practical applications, and encouraging the adoption of a practical perspective. This format encouraged independent research, critical thinking and creative communication. Topics covered included AI in classroom teaching, assessment, language support, and school resources, as well as comparative perspectives on international education systems.

The seminar also addressed key ethical and societal issues surrounding the use of AI in schools, promoting competencies related to human agency, accountability, and social responsibility. Future teachers received a theoretical introduction to AI concepts and application areas, and were encouraged to explore the implications and challenges for pedagogy. Throughout the course, collaborative reflection and discussion supported the development of a professional stance towards AI in education. By aligning the content and methods of the seminar with the UNESCO framework, the course aimed not only to build AI-related knowledge and skills, but also to promote students' confidence, ethical awareness, and readiness to meaningfully integrate AI into future educational practice.

Rationale of the Study and Research Questions

Despite the growing importance of AI in education, research into how teacher training prepares educators to engage with and teach about AI is still in its infancy (Sperling et al., 2024; Tan et al., 2025). Most existing studies focus on AI as a teaching tool, rather than on developing the competencies required for critical and pedagogical engagement with AI. Key factors such as AI readiness, perceived relevance and confidence in teaching AI influence whether teachers engage with AI content; however, these factors remain under-explored in pre-service teacher education (Ayanwale et al., 2024). At the same time, barriers such as limited technological knowledge, low awareness of and acceptance of AI among teachers, and ethical concerns hinder its effective integration into professional practice (Tan et al., 2025). In addition, comprehensive AI literacy encompasses not only knowledge, but also practical skills and professional judgment – dimensions that are rarely examined together in empirical studies (Sperling et al., 2024).

This study addresses these research gaps by investigating how future teachers' knowledge, attitudes and reflections on AI evolve in a postgraduate seminar. It contributes to the development of evidence-based teacher education in the age of AI. In this context, the present study examines how future teachers' perceptions of AI in schools change through in-depth engagement with AI-related topics during a postgraduate teacher training course. The following research questions guide the study:

RQ1: What knowledge and attitudes do teacher education students have regarding the use of artificial intelligence in school contexts?

RQ2: How do their knowledge and attitudes change over the course of a university seminar on AI in education?

RQ3: What themes emerge concerning the opportunities, challenges and risks of using AI in schools?

Study Design and Data Collection

To explore the effects of engaging with AI-related issues in a university seminar on future teachers' attitudes towards and knowledge of AI in education, a pre-post mixed-methods design was implemented. Data was collected using a standardized questionnaire administered through Google Forms. The questionnaire was distributed at two points in time: at the beginning of the semester (pre-survey) and at the end of the course (post-survey). It addresses two central areas: (1) teacher education students' self-perceived knowledge of AI concepts and their application in schools, and (2) attitudes and perceptions regarding the use of AI in educational contexts and teaching.

The questionnaire was developed by the authors based on the UNESCO AI Competency Framework for Teachers (2024), which also guided the seminar concept. It consisted of 20 AI-related items in total. Five open-ended questions invited students to describe their associations with AI in schools, reflect on previous experiences with AI, and to give reasons for their attitude on AI. They were supplemented by a list of closed-ended items. Eleven 5-point Likert-type items were used to capture future teachers' attitudes and perceptions of AI in education (e.g., "To what extent do you agree or disagree with the following statement on AI in education? By using AI, students' individual learning processes can be supported." 1 – strongly disagree to 5 – strongly agree). Three 5-point rating-scale items asked students to evaluate their knowledge on AI in general, AI in education and their attitude towards AI use in educational contexts (e.g., "How would you rate your current level of knowledge about AI in general?" 1 – very low to 5 – very high). Another closed-response item gathered information on prior personal experience using chatbots for their university courses. The open-ended questions encouraged reflective responses, providing insights into individuals' perspectives and thought processes, while the closed questions aimed to capture measurable indicators of teacher education students' knowledge levels and attitudes towards AI in schools. As contextual information, the questionnaire also included two items on whether the students were already working as teachers at a school, and if yes, to what extent.

Sample

The initial survey was completed by all the teacher education students attending two seminar groups following the described teaching concept on AI (N=45), while the final survey was completed by 38 students. There were no missing values, as this was ensured by the settings of the data collection form. The sample consisted of Master's-level student education teachers who were nearing the completion of their program. In total, 30 students (66.7%) reported that they were already working as a teacher in

schools, with teaching commitments ranging from 8 lessons per week (approximately a 40% part-time position) up to 27 lessons per week, which exceeds a full-time role. Participation in the questionnaire was voluntary and anonymous. All data were processed in accordance with data protection regulations.

Participants were automatically assigned to one of ten seminar groups based on a preference system via the university registration system. The seminar focus on AI and school was independently selected by the lecturers of the two relevant groups. The sample includes all students from the two seminar groups and therefore represents the full cohort for this course. Similar studies in teacher education have found that sample of this size are sufficient for a predominantly exploratory study (Mertens, 2014).

Data Analysis

Open-ended responses were analyzed using qualitative content analysis based on Mayring's (2023) approach. MAXQDA software was used to conduct the analysis, applying inductive category development to identify recurring themes, patterns of argumentation and student perspectives emerging from the data. This inductive approach enabled new, context-specific categories to be derived directly from the teacher education students' responses. The qualitative analysis offered a deeper interpretation of the quantitative results, enriching the findings through a multi-method approach (Flick, 2011). Closed-ended questions were analyzed descriptively in SPSS by calculating frequencies, means, and standard deviations to identify key trends and changes between the two survey points. This form of descriptive statistics provided a structured, quantitative overview of the students' knowledge and attitudes supplementing the findings from the qualitative analyses (Döring, 2023; Field, 2018).

FINDINGS

Future Teachers' Knowledge and Attitudes on AI

To begin with, the data from the pre-seminar survey are used to describe Austrian teacher education students' knowledge and attitudes regarding AI independent of the specific seminar on AI in education. The findings show that teacher education students view AI as a key educational topic. They believe that schools should respond to societal developments, a view that applies to both teachers and students. *"Schools must also operate in the current age and adapt to it. For these reasons, technology and AI must also find their way into schools"* (Q16). This view is supported by survey results showing that 73% of respondents consider integrating AI into education to be a progressive and necessary step, while only 11% oppose it. This strong majority highlights a clear demand for schools to adapt to technological advancements and prepare learners for an AI-influenced future.

At the beginning of the seminar, teacher education students' thoughts on AI in schools were relatively general. They primarily referred to changes in everyday school life affecting both teachers and learners. Future teachers predominantly perceived AI as a supportive tool that could simplify the everyday tasks of teaching professionals. Its potential applications in lesson planning, generating new ideas and perspectives on a

topic, and creating teaching materials were frequently mentioned. *"AI can be a great help when preparing teaching materials because, based on a good prompt, it can quickly generate suitable examples that are similar to the examples I give AI. This is of course a great help when preparing lessons"* (QR 42). AI was also seen as an opportunity to promote personalized learning and integrate it more effectively into day-to-day school routines. *"However, initial studies already show that the individual learning path and learning success of pupils working with AI can be improved"* (QR 18). According to the teacher education students, productive, learning-oriented use of AI requires teachers to have a basic understanding of AI themselves. Similarly, pupils need to learn how to use AI tools and critically evaluate their potential and risks. The importance of analyzing and discussing possible dangers was emphasized. *"I think that AI is often misused to make one's own work easier, if not to have it completely solved by programs like ChatGPT. I think younger pupils can be very naive/careless/unreflective with these programs and there are many dangers"* (QR 19).

The survey also provided insights into teacher education students' prior experience with AI in their role as university students. At the start of the course, four students (11%) reported never having used AI tools, 18 (40%) indicated occasional use, and 22 (49%) reported frequent use. Experience with AI in school contexts varied considerably. Students already working as teachers reported specific applications, such as creating teaching materials and tasks, as well as lesson planning. They also observed that pupils often used AI tools to assist with homework. Other reported uses included generating texts, translating content, improving written language, and conducting research. However, many students – especially those without teaching experience beyond placements – stated that they had not yet had any direct experience of using AI in a school setting.

As part of the survey, future teachers were asked to assess their current knowledge of AI in general, and its use in schools specifically, using a five-point Likert scale (1 – very low; 5 – very high). Table 1 shows teacher education students' self-assessment of their knowledge and their general attitudes towards the use of AI in schools. Regarding general knowledge of AI, at the beginning of the seminar, none of the respondents rated their knowledge as 'very low' (level 1) or 'very high' (level 5). Thirteen students (31%) selected level 2, while 20 (47%) assessed their knowledge as medium (level 3). A further 10 students (22%) indicated a relatively high level of knowledge (level 4). Overall, the responses suggest that most teacher education students considered themselves to have a moderate understanding of AI; no participants rated themselves as either completely inexperienced or highly knowledgeable. In contrast, self-assessment of knowledge about AI in school contexts yielded lower ratings. Three students (7%) rated their knowledge as very low (level 1); 18 (42%) selected level 2; and 19 (44%) chose level 3. Only three students (7%) indicated a relatively high level of knowledge (level 4), and once again, no participant selected the highest level (5). These findings indicate that students felt less confident in their knowledge of AI in educational settings compared to their understanding of AI in general.

Table 1
Self-assessed knowledge of AI (general and in educational contexts) and attitudes towards AI in education (prior to the seminar)

Self-assessed knowledge …	(1) very low		(2)		(3)		(4)		(5) very high	
	N	%	N	%	N	%	N	%	N	%
… of AI in general	0	0,0%	14	31,1%	21	46,7%	10	22,2%	0	0,0%
… of AI in education	3	6,7%	19	42,2%	20	44,4%	3	6,7%	0	0,0%
Attitudes on AI use …	(1) very negative		(2)		(3)		(4)		(5) very positive	
	N	%	N	%	N	%	N	%	N	%
… in educational contexts	1	2,2%	3	6,7%	15	33,3%	15	33,3%	11	24,4%

In addition to assessing their knowledge, teacher education students were asked to rate their general attitude towards the use of AI in schools on a five-point scale (1 = very negative; 5 = very positive; see Table 1). The responses indicated a predominantly positive attitude towards AI in education. Only one student (2%) expressed a very negative stance (level 1), while three (7%) selected level 2, indicating a somewhat critical view. In contrast, a large proportion of participants held a neutral to positive view. Fourteen students (33%) chose level 3, another 14 (33%) selected level 4 and 11 (24%) expressed a very positive attitude by selecting level 5. These results show that, while a small minority of future teachers were skeptical, the majority viewed the integration of AI into educational settings with openness and optimism at the beginning of the seminar. The high number of responses at levels 4 and 5 point to a readiness to engage constructively with AI as a meaningful and beneficial teaching and learning tool.

Seminar-driven Developments in Knowledge and Attitudes

The data show that both the teacher education students' level of knowledge and their attitudes towards AI in education changed over the course of the seminar. Notably, there were positive developments in their perceived knowledge and their stance on the use of AI in schools. Figure 1 shows a clear upward trend in students' self-assessed knowledge of AI, both in general and particularly in relation to its use in educational contexts. In total, Figure 1 illustrates that the teacher education students' knowledge regarding AI in general as well as AI in educational contexts increased between the beginning and the end of the seminar according to their own estimation. While approximately one third of the students initially rated their general knowledge of AI as rather low (31% at level 2) and almost half assessed their knowledge of AI in education as (rather) low (7% at level 1 and 42% at level 2), by the end of the seminar only just over 10% remained at level 2 (13% for general AI knowledge and 11% for knowledge of AI in education). On the other side of the spectrum, the proportion of teacher education students rating their knowledge as rather high increased substantially, from 22% to 37% at level 4 regarding knowledge of AI in general, and from 7% to 39% at level 4 for knowledge of AI in education.

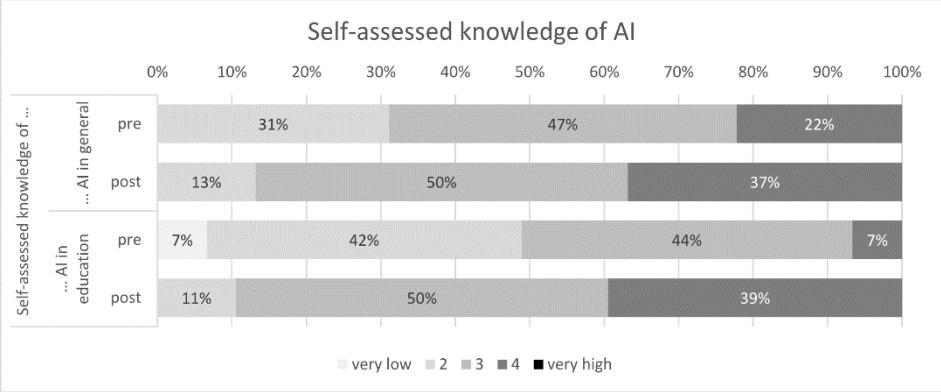

Figure 1
Self-assessment of AI-related knowledge (in general and in educational contexts) prior to and after the seminar

Regarding teacher education students' attitudes towards AI, the proportion of negative responses declined over the semester: in the post-seminar survey, no students selected level 1 and only three (8%) chose level 2. Neutral attitudes (level 3) also decreased, with only 9 future teachers (24%) selecting this option. Conversely, the number of students selecting level 4 increased significantly, with 21 (55%) choosing this option, while only 5 (13%) selected level 5. Overall, the data reveal a clear shift towards more positive evaluations of AI in educational contexts, accompanied by a decline in neutral and ambivalent positions. While around one-third of teacher education students had initially held a neutral view, over half expressed a clearly positive stance at level 4 after the seminar. Notably, both critical or uncertain views, as well as unreservedly positive attitudes (at level 5) declined.

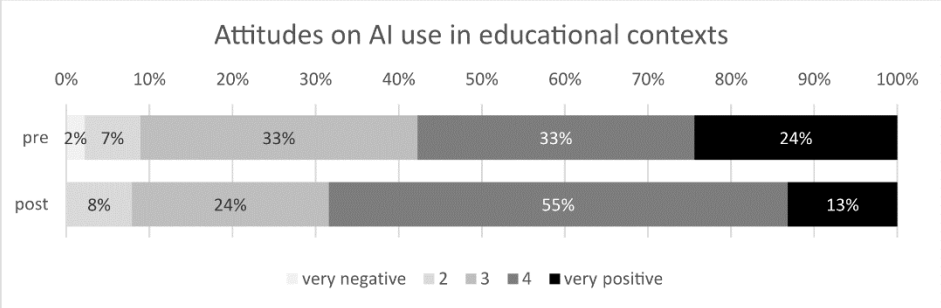

Figure 2
Students' attitudes towards the use of AI in educational contexts before and after the seminar

By the end of the semester, it was clear that students had improved their ability to articulate their thoughts on AI in education more precisely and were engaging with the topic more critically. Most participants were able to discuss the opportunities and

challenges of using AI in schools, supporting their arguments with knowledge acquired during the course. Compared to their initial responses, they showed significant progress in critically reflecting on key AI-related issues such as resource consumption, data privacy, and ethical implications. *"On the one hand, I see great potential in AI support (relieving the burden on the teacher, individualization, idea generation, etc.). On the other hand, there are numerous problems (availability, ethical questions, lack of autonomy and creativity, energy consumption, etc.)"* (QR 35). Teacher education students increasingly emphasized the importance of using AI appropriately and responsibly, developing the necessary skills, and accepting the challenges that AI may represent. *"But I'm also concerned about the impending loss of skills; I fear that students will no longer learn certain skills as well because AI will do the work for them"* (QR 2). A major challenge here is that skills are often lost through the use of AI. *"In the education sector, AI is criticized because students no longer think or write independently as a result"* (QR 13).

The future teachers pointed out that it is important for pupils to learn how to use AI correctly. *"In my opinion, it is wrong to devalue AI and view it as a danger. It is much more important to teach young people and adolescents the right way to deal with it – especially in their role as teachers"* (QR 33). They argued that, while AI can be a valuable learning companion and supportive tool that can aid individual learning and help ease teachers' workloads, it cannot replace the role of the teacher. *"Even as a teacher, AI will never replace their work/profession, because AI can never come close to heartfelt praise, a friendly smile or even just an honest confidant"* (QR 5). They particularly highlighted that essential components of education, such as social interaction and emotional engagement, are not adequately addressed by AI applications. In this context, teacher education students also stated that AI cannot replace human abilities. *"In particular, AI should not be seen as a substitute for human skills, as it can only ever serve as a support"* (QR 7). This view was supported by survey results at the end of the semester, which showed that 74% of students rejected the notion that AI leads to alienation between teachers and learners, with no respondents fully agreeing. Additionally, 76% agreed that AI can support individual learning paths more effectively, and 92% acknowledged that AI can relieve teachers of certain tasks, such as lesson planning.

By the end of the seminar, teacher education students were able to name a wider range of potential AI applications in education and to critically evaluate them. A recurring concern was that teachers were insufficiently prepared to support pupils in developing critical AI literacy. Future teachers also emphasized the importance of questioning AI-generated responses – a point some had already raised at the beginning of the course. According to the respondents, while AI can offer new ideas and perspectives, it must be used with caution and reflection: *"However, it is important to practice the responsible use of AI tools and to pass this on to the children. Without critical analysis and reflection, the use of AI in schools can have negative consequences"* (QR 16). At the same time, some students expressed concern that this responsibility could become an added burden for teachers. *"Another thing that teachers have to take care of: As a teacher, you are already responsible for so many things and now I fear that teaching a responsible approach to AI will also become our task. I think it would be very cool if*

external experts came to the school and explained this to the pupils" (QR 34). Several students also argued that teachers need more knowledge and skills related to AI in order to be able to use it effectively to promote learning: *"Teachers certainly need to be made more aware of this and informed about the possibilities, as older teachers in particular often have no knowledge of it"* (QR 34), so that the fears that are addressed can be dealt with professionally. *"On the one hand, there is uncertainty and concern about not knowing enough about AI and therefore not being able to do a good job"* (QR 15).

DISCUSSION

The results show that future teachers perceive AI in education as a relevant and forward-looking topic, and are generally positive about its use in schools. This aligns with the theoretical assumption that future teachers will play a pivotal role in imparting digital and AI-related skills (Mulvihill & Martin, 2024; UNESCO, 2024). Almost three-quarters of respondents support the use of AI in schools, recognizing its potential to assist teachers and promote personalized learning. At the same time, a differentiated approach to opportunities and risks, along with reflective use by both teachers and students is emphasized. While the data highlight a high awareness of AI, many teacher education students initially showed limited practical knowledge and self-confidence regarding AI applications in school contexts, which reflects findings from previous studies (Ayanwale et al., 2024; Fassbender, 2024). Through their engagement with AI-related topics in the seminar, students acquired essential theoretical foundations, gaining a more solid understanding of AI's role and potential in education. By having students produce podcasts for each other, the seminar explicitly demonstrated possibilities for integrating AI methodically and with various programs into both general and subject-specific teaching in the future, highlighting the associated risks as well as opportunities. The seminar's practical orientation allowed students to critically explore how AI can be integrated into classroom settings, with opportunities to pursue personal interests within the topic fostering greater motivation and deeper engagement. In particular, the production of a podcast as a seminar output supported self-directed learning and reflection, strengthening students' ability to critically assess AI applications. Students with practical teaching experience, however, demonstrated greater knowledge in handling AI. Concerning research question 1, we can summarize that Austrian teacher education students show a positive attitude towards the use of AI in educational contexts, while they rate their competence to use AI independently in their work as teachers as rather low – particularly those who have not yet started working as a teacher. This underscores the importance of aligning teacher education programs with the development of AI-related knowledge, judgment and skills (Meylani, 2024; Tan et al., 2025). The seminar combined active learning, theory-based reflection, and independent research, all structured around the UNESCO AI Competency Framework (UNESCO, 2024), and demonstrated promising approaches. Ethical issues and risks – particularly those concerning younger learners – were addressed early in the seminar, reflecting the critical awareness and pedagogical responsibility encouraged by the UNESCO framework (UNESCO, 2024; Song & Ko, 2024).

Regarding research question 2, following the seminar, a higher proportion of teacher education students reported a high level of knowledge of AI in education and a more

critical and reflective attitude towards it. These enhanced reflective abilities manifested as nuanced views on equity, data protection, the role of the teacher, and student responsibility. This suggests a process of professionalization that fosters a critically reflective approach to digital technologies – a key goal in teacher education (UNESCO, 2024). Discussions and individual reflections during the seminar, in particular, contributed significantly to this shift in perspectives, encouraging students to critically evaluate the implications of AI. A more detailed analysis of which particular seminar elements (such as ethical discussions, case studies, or the podcast project) contributed to this shift would provide valuable insights into the effectivity of specific methods. However, it is important to note that increased self-confidence does not automatically translate into actual competence. Qualitative analyses show that after the seminar, teacher education students were able to identify a broader range of AI applications and engage more deeply with the associated challenges.

Concerning research question 3, the main opportunities identified lie in personalizing learning processes, providing administrative relief, and enabling new access to learning (Rasul et al., 2023; Tan et al., 2025). Conversely, risks such as information overload, ethical dilemmas, and potential loss of competence among learners were also discussed by the future teachers.

In future research, conducting interviews with teacher education students would provide valuable insight into changes in their knowledge and skills regarding AI and how these developments are linked with specific seminar elements. This would complement the self-assessment data used in this study. Among the many implications of AI in education, its effect on social interaction and emotional connection stands out as especially significant. AI can potentially free up teachers' time, enabling them to prioritize social interactions, emotional support and relationship building. This broadens the scope of the teacher's role to include pedagogical guidance and reflection (UNESCO, 2024; Song & Ko, 2024). At the same time, teacher education students emphasized that AI should not be used to replace human interaction. This aligns with research findings in the context of kindergarten principals by Ali (2025). They pointed out that the emotional nuances and social dynamics of the classroom are difficult to replicate digitally, posing the risk of creating 'dehumanized' learning environments (Meylani, 2024). In addition, ethical issues such as data privacy breaches, algorithmic bias, and social inequalities could undermine trust in AI technologies (Ayanwale et al., 2024; UNESCO, 2024). Future teachers recognize the important role of educators in critically evaluating AI and in guiding learners to use it responsibly (Lee, 2019). However, this requires teachers to possess the necessary knowledge and skills to convey this competence professionally. This ambivalent perspective highlights the urgent need to orient teacher education not only towards technical skills but also towards the social and ethical dimensions. Future teachers must be equipped to utilize AI critically and responsibly, while preserving the interpersonal and emotional aspects of teaching and fostering social dynamics (Song & Ko, 2024; Tan et al., 2025).

The limitations of this study include the small sample size, its focus on a single teacher education institution the reliance on self-assessment data. These factors limit the

generalizability of the findings and should be taken into account when interpreting the results.

CONCLUSIONS

The present study shows that Austrian teacher education students report only moderate knowledge of AI, especially in educational contexts, by the end of their initial training. The findings also indicate that a seminar combining theoretical input and practical engagement with AI in schools can significantly enhance future teachers' understanding of and critical reflection on AI. This provides important empirical support for structurally integrating AI education into teacher education programs. In particular, combining knowledge acquisition, ethical reflection and practical application appears effective in fostering a professional stance towards AI. However, the sustainable integration of AI in schools requires more than technical expertise; it also demands pedagogical and ethical judgment – a triad that should be systematically addressed in teacher education.

Consequently, clear recommendations for teacher education emerge: content on ethical reflection, practical application and critical engagement with AI should be systematically integrated. Learning formats that combine theoretical foundations with active, reflective approaches, such as project work, case studies or practice-oriented simulations, are particularly effective. This approach can help bridge the gap between theoretical frameworks and school practice. Furthermore, lecturers‘ professionalism is key. Teacher educators also require a high level of professional AI-related knowledge, need to be able to use AI-tools and critically reflect on their potentials and associated risks.

The present study used student-produced podcasts as an innovative format in combining theory and practice for teacher education students. The specific potentials of this element for the learning process and for assessment should be explored in-depth in future studies. With the UNESCO AI competency framework (UNESCO, 2024), the seminar has a sound theoretical basis founded in the current international discourse about teachers’ professional development regarding AI.

Further research is needed to investigate the long-term effects of such educational formats and assess the effectiveness of different didactic approaches in fostering sustainable competency development. From a policy perspective, these findings underscore the need to embed AI education as a core part of teacher education to ensure that educators are equipped to navigate the challenges and opportunities of an increasingly digital school environment.

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