

Generative AI in teacher education: Educators' perceptions of transformative potentials and the triadic nature of AI literacy explored through AI-enhanced methods

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ABSTRACT

The release of ChatGPT in November 2022 has sparked discussions about integrating Generative Artificial Intelligence (GenAI) into teacher education. Teacher educators, as key facilitators of pre-service teacher learning, play a critical role in shaping the successful adoption of GenAI. Their perceptions guide curriculum redesign, define promoted practices, and shape how pre-service teachers experience educational uses of GenAI tools, potentially multiplying its impact across future classrooms.

This mixed-methods study explored Danish teacher educators' perceptions of GenAI (n = 91), focusing on its transformative potential and the knowledge pre-service teachers need to acquire. Innovative methods, including GenAI-supported thematic analysis and Natural Language Processing, were used to analyze qualitative and quantitative survey data.

Findings reveal diverse perceptions, ranging from enthusiasm for fostering innovative teaching to concerns about ethics, assessment, and safeguarding basic skills. Concerning GenAI's potential, three key themes emerged: AI literacy, AI didactics, and AI assessment. Regarding required knowledge, teacher educators emphasized multifaceted AI literacies (AI as a teaching tool, as teaching content, and as a learning tool) framed within ethical, cultural, and democratic contexts. Mediation analyses showed that GenAI use mediated the link between both intrinsic motivation and confidence, and perceptions of its potential.

Importantly, teacher educators identified a pressing need for both formal professional development and informal, collaborative learning opportunities. This study extends the TPACK framework by incorporating the triadic nature of AI literacy and emphasizes the importance of preparing educators to engage critically and responsibly with GenAI in education.

1. Introduction

With the release of ChatGPT in November 2022, teacher education institutions and educators have been discussing how to incorporate Generative Artificial Intelligence (GenAI) into their educational programs. Teacher educators' perceptions of GenAI's role in teacher education will guide curriculum redesign, define the practices they promote, and shape how they support pre-service teachers' early experiences with GenAI in teaching practice (Korthagen, 2016; Moorhouse &

Kohnke, 2024). As teacher educators play a crucial role in determining the practices and beliefs of pre-service teachers (Bai & Ertmer, 2008), their integration of GenAI into teacher education is likely to have a multiplying effect. After teacher education, pre-service teachers will transfer their educational experiences to future classrooms, impacting school students. Hence, teacher educators' perceptions of GenAI in teacher education play a significant role in determining its successful adoption both at teacher education institutions and at schools.

In general, research shows that higher education teachers are slow to

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adopt new technologies (Brown, 2016; Liu et al., 2020). However, GenAI, such as ChatGPT or Claude, differ from prior educational technology concerning its accessibility, versatility, and pervasive nature in society in general (Kasneji et al., 2023). Due to their capabilities, GenAI tools are seen as a disruptor of the status quo in education but also a catalyst for rethinking learning and teaching (Jensen et al. 2024). Researchers highlight both the potential benefits of GenAI for education and its possible risks to student learning (Abbas et al., 2024; Hansen et al., 2025; Kasneji et al., 2023). Consequently, educators acknowledge that they have to adapt rapidly to the opportunities and challenges brought on by GenAI (e.g., McGrath et al., 2023; Moorhouse & Kohnke, 2024). Despite their crucial role, teacher educators' perceptions are underexplored. To date, only Moorhouse and Kohnke (2024) have examined English language teacher educators' perceptions of GenAI, focusing on the early months following ChatGPT's release, a time when institutions and educators were just beginning to adapt to this emerging technology.

This study therefore examined teacher educators' perceptions of the potential impact of AI on teacher education and the essential knowledge pre-service teachers need to acquire. To better understand the factors shaping teacher educators' perceptions, the study also investigated the roles of confidence, intrinsic motivation, and teacher educators' use of AI in teaching. Using a mixed-methods approach, the study collected both qualitative and quantitative data from teacher educators teaching at all Danish teacher education institutions. In addition to traditional methods, the research incorporated innovative techniques, such as Natural Language Processing and GenAI-enhanced thematic analysis.

Consequently, this study sheds light on teacher educators' perceptions of AI in teacher education and factors shaping these. It offers insights into reimagining teaching and learning in the GenAI era and outlines the skills that teacher educators believe pre-service teachers must develop. Based on this, the study thus highlights key areas for professional development and identifies essential components of AI literacy for teacher education programs. Furthermore, it provides insights into how Natural Language Processing and GenAI can assist qualitative and quantitative-qualitative data analysis in educational research.

2. Literature review

2.1. Opportunities and challenges of GenAI in education

GenAI tools are based on large language models trained on massive amounts of data and have impacted the educational landscape due to their accessibility and diverse applications. In response to prompts (e.g., instructions, questions) they generate new, human-like content (e.g., images, text) and imitate human abilities and skills, such as identifying patterns or making decisions (Kasneji et al., 2023; Sheikh et al., 2023). This technical capability presents significant opportunities in education, for enhancing student learning and reducing teacher workload. From a learner perspective, key benefits of GenAI tools in educational contexts include tailored support for individual learning needs, personalized feedback, or creating new learning situations with artificial conversation partners (Kasneji et al., 2023; Wu & Zu, 2023). While these capabilities can promote student learning, they also require educators to rethink teaching, learning, and assessment (Dawson et al., 2024; Jensen et al. 2024; Mah et al., 2023). From an educator's perspective, a professional use of GenAI tools can also be beneficial to their work. GenAI tools can assist with organizational tasks, lesson planning, materials preparation, and assessment, allowing for a more focused approach to individual student support (Celik et al., 2022; Jensen et al. 2024).

However, despite the potential outlined, the integration of GenAI tools in education is not without its pitfalls. Increased reliance on GenAI tools could risk limiting a person's ability to solve problems independently as well as their critical thinking, interpersonal competencies, and retention of core academic skills (Farrokhnia et al., 2023; Kasneji et al., 2023). Furthermore, users need to be capable to evaluate GenAI output

to detect misinformation generated by GenAI tools (Ng et al., 2023). In addition, the integration of GenAI is challenging traditional assessment practices. GenAI tools make it difficult to verify independent authorship in student work. Hence, the educational community is currently debating when GenAI should be integrated into assessments tasks (Dawson et al., 2024; Lodge et al., 2023).

2.2. The need for AI literacy in education

Given GenAI's transformative potential in education, educators need to be enabled to use AI tools effectively to harness its benefits while mitigating its risks. Hence, educators need to acquire AI literacy. A notable definition of AI literacy, as proposed by Long and Magerko (2020), characterizes it as "a set of competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace" (p. 2). This definition has evolved to differentiate between generic AI literacy, a fundamental understanding of AI, and domain-specific AI literacy, which pertains to AI applications in specific fields such as medicine or education (Knoth et al., 2024; Mah & Groß, 2024; Ng et al., 2021).

In education, AI literacy represents a significant challenge for educators and students (Bond et al., 2023; Ifenthaler et al., 2024). Emotional and motivational barriers, such as anxiety and discomfort, further complicate AI literacy adoption (Yang et al., 2025). In light of the recent advances and rise of generative AI, a number of institutions have begun providing guidelines and developing frameworks to enhance AI literacy for both educators and students (Celik, 2023a; Chiu et al., 2024; Wang & Lester, 2023). For instance, the TPACK framework has been adapted to the GenAI era (Mishra et al., 2023; Mishra & Koehler, 2006). TPACK consists of three major components of teacher knowledge: content (CK), pedagogy (PK), and technology (TK) with their intersections of pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK; Mishra & Koehler, 2006). Celik (2023b) extended the TPACK framework with the knowledge of ethical aspects and proposed the Intelligent TPACK framework. UNESCO (2024) introduced a global AI competency framework for educators, highlighting competencies such as human-centered mindset, AI ethics, and AI pedagogy. Concerning AI pedagogy, educators require the "capacity to critically adapt and creativity explore innovative practices in the context of advancing capabilities of emerging AI iterations" (p. 23).

2.3. The role of teacher educators in AI adoption

In teacher education, teacher educators can be assumed to have significant impact on how pre-service teachers acquire AI literacy and, as a result, how GenAI is implemented in pre-service teachers' future classrooms (Moorhouse & Kohnke, 2024). Teacher educators bridge theory and practice by demonstrating professional teaching through explicit methods, such as lectures and tutorials, while implicitly modeling reflective and innovative teaching practices. Furthermore, they help pre-service teachers integrate theoretical knowledge with practical learning opportunities (European Commission, 2013). Beyond their teaching role, teacher educators contribute significantly to curriculum development. They delineate learning outcomes, guide pre-service teachers, and assess their progress (Korthagen, 2016; Moorhouse & Kohnke, 2024).

Teacher educators' perceptions guide their educational practices (Pajares, 1992). Perceptions are the opinions, beliefs, and attitudes that individuals hold about particular topics or issues. They reflect how individuals perceive, interpret, and respond to their environment (Abel et al., 2022; Zhai, 2024). Educators' perceptions are formed by their experiences (Pajares, 1992). Perceptions are influenced by, for example, a person's intrinsic motivation or confidence to engage with educational technology (Ayanwale et al., 2022; Deci & Ryan, 2000; Ertmer, 2005). In

the context of teacher education, intrinsic motivation and confidence may lead teacher educators to use GenAI tools themselves and alter their perception of the value of these tools for teacher education. Hence, understanding teacher educators' perceptions of GenAI and factors contributing to them is essential for addressing potential misconceptions and equipping them to integrate GenAI effectively into educational practices. However, to date, there has only been one study (Moorhouse & Kohnke, 2024) focusing specifically on teacher educators' perceptions of AI from the first months of ChatGPT availability (April 2023). Moorhouse and Kohnke interviewed thirteen teacher educators at universities in Hong Kong offering language education. Their findings indicate that participants anticipate GenAI tools will have a significant impact on the curriculum, instruction, and assessment. Participants believed they could play a crucial role in modeling the use of GenAI tools, but felt they lacked guidance concerning assessment in a GenAI world. The majority of participants expressed concerns about their own AI literacy in effectively addressing the challenges and opportunities posed by these tools.

Research regarding technology in general and not focusing on teacher education exclusively, offers additional insights. Concerning technology in general, research consistently indicates that higher education teachers tend to adopt new technologies at a slow pace (Liu et al., 2020). Teacher educators, at times, struggle to recognize the rationale for integrating technology (Ngao et al., 2022). Contributing factors include educators' anxiety about adopting new technologies (Zimmerman, 2006) and a tendency to remain within their comfort zones, relying on familiar materials and methodologies (Tallvid, 2016). Educators who view GenAI as tools that enhance their instructional practices are more inclined to adopt its use in the classroom (Kaplan-Rakowski et al., 2023). In general, GenAI may lead to a different response. Moorhouse and Kohnke (2024) found that teacher educators perceived GenAI as a "fundamentally different technology from other technological advances" (p. 8). This is supported by findings from the general higher education field. Ofofu-Ampong (2024) found that a large amount of higher education teachers expressed willingness to accept AI integration. Furthermore, Mah and Groß (2024) found that higher education faculty saw greater equity in education as the biggest benefit of AI, while the lack of AI literacy among students and faculty was among the greatest challenges. In addition, faculty members were highly interested in pursuing professional development opportunities in the field of AI. McGrath et al. (2023) found participants assessed their AI literacy and the impact on equity differently. Higher education teachers reported concerns about AI adoption, including fears and skepticism regarding its fairness and ethical implications, as well as a lack of knowledge and resources needed to integrate AI effectively into teaching practices.

3. Research questions

Given the crucial role of teacher educators in teacher education, this article investigates the following research questions.

- What are teacher educators' perceptions of the potential of AI for teacher education?
- How do intrinsic motivation, confidence, and the use of AI in teaching influence teacher educators' perceptions about the potential of AI in teacher education?
- Which AI knowledge do teacher educators perceive as crucial for pre-service teachers?

4. Method

4.1. Sample and procedure

Teacher educators from all university colleges in Denmark were invited to participate in the study ($n = 693$). The research team compiled

all publicly available email addresses of educators working in teacher education from the UC Viden (ucviden.dk) database, where they are listed under their respective institutions. Consequently, the sole inclusion criterion was employment in Danish teacher education. Data collection took place between May and June 2024, during which educators received a survey link via SurveyXact along with a request to participate in the study. Participants did not receive any financial compensation. The survey took approximately 15–20 min to complete.

In total, 91 teacher educators (59.3 % female, 38.9 % male, 1.1 % no disclosure) completed the survey. They were largely from the age groups 50–59 (36.3 %) and 60–69 (34.1 %) (30–39 years old: 3.3 %, 40–49 – 9.9 %, 70 or older: 15.4 %, no disclosure: 1.1 %) and had a large variation of teaching experience at university college (3–6 years: 25.3 %, 7–9: 12.1 %, 10–19: 13.2 %, 20–29: 25.3 %, 30–39: 20.9 %, 40 or more: 3.3 %). Most participants were either associate professors (64.8 %) or assistant professors (26.4 %) and employed at one of the VIA university colleges (33 %; Absalon: 7.7 %, Copenhagen: 11 %, Lillebælt: 9.9 %, Nordjylland: 11 %, Syd: 11 %, no disclosure: 16.5 %). The response rate of 13.13 % was comparable to similar open survey studies (e.g., Byman et al., 2020).

Ethical approval for the study was obtained from the Ethics Review Board at Aarhus University (ID: BSS-2024-066-A). All participants received written information detailing their rights, the study's purpose, its procedures, and provided active consent before participation.

4.2. Research rationale

This study employs a mixed-methods approach to examine teacher educators' perceptions of AI in teacher education (Creswell & Plano Clark, 2017). Quantitative analyses are complemented by qualitative analyses to provide a comprehensive understanding of teacher educators' views. The analytical aim is to explore how teacher educators perceive AI's potential, the factors influencing these perceptions—particularly their intrinsic motivation, confidence, and use of AI in teaching—and the AI knowledge they believe pre-service teachers need to acquire. To deepen this understanding, qualitative analyses investigate the specific potentials teacher educators identify and the knowledge they deem essential for pre-service teachers. By integrating these methods, the study offers both a broad overview of teacher educators' perceptions and the factors shaping them, as well as conceptual insights drawn from their perspectives.

4.3. Instruments

Participants completed subscales on intrinsic motivation for learning about AI and confidence of using AI from the AI literacy questionnaire developed by Ng et al. (2023). The scale on intrinsic motivation consists of four items (e.g., *I am curious about discovering new AI technologies.*). Teacher educators' confidence of using AI was assessed with five items (e.g., *I can make good use of AI related tools.*). Teacher educators were asked to judge the statements on a 6-point Likert scale, ranging from "strongly disagree" to "strongly agree". Internal consistency coefficients (Cronbach's $\alpha_{\text{intrinsic motivation}} = .82$, $\alpha_{\text{confidence}} = .85$) were good.

Concerning teacher educators' use of AI for teaching, the research team developed its own survey based on a recent instrument from another AI study (von Garrel & Mayer, 2023) as no suitable survey instrument was available at the time of the study. To ensure content validity, two members of the research team created the initial items based on the study's conceptual framework, recent literature, and their experience as researchers in teacher education and AI. In the next step, the four remaining members of the research team reviewed the items to refine their wording and ensure they appropriately covered the teacher educators' uses of AI. The survey assessed a wide range of applications, including planning, material creation, assessment, and feedback (see Appendix 2). To examine the scales internal structure, an exploratory factor analysis (principal axis factoring) was conducted. The scree plot

showed a clear drop after the first factor, which accounted for 53.6 % of the total variance. Hence, the exploratory factor analysis supported a one-factor solution, reflecting a general construct of AI use by teacher educators. To assess the reliability of the instrument, internal consistency was calculated using Cronbach's alpha, which showed excellent reliability, $\alpha = .91$. The scale consists of eleven items (e.g., *In the context of my teaching, I use AI for creating teaching materials for myself*; *In the context of my teaching, I use AI to generate feedback for students*). Teacher educators rated the statements on a 6-point Likert scale, ranging from "not at all" to "very often".

4.4. Teacher educators' perceptions

The survey contained two open-ended questions. The questions were based on previous studies (Antonenko & Abramowitz, 2023; Moorhouse & Kohnke, 2024) that explored educators' perceptions of AI in education. Teacher educators were asked, "What do you think about the potential of AI to influence teacher education?" and "What do you think is important for student teachers to understand about AI?". While answers to both questions were analyzed using thematic analysis (for details see below), sentiment analysis was conducted on answers to the first question to be able to analyze the qualitative data in combination with the quantitative data. For sentiment analysis (Falcon & Leon, 2023) it was important to use an open-ended question that allows participants to consider both positive and negative possibilities, enabling them to explore both benefits and drawbacks of AI's impact on teacher education.

The sentiment analysis was conducted using the pre-trained Asent model (Enevoldsen, 2022). It utilizes natural language processing methods, like tokenization, to extract features from textual data. Hence, it divides the text into units of analysis called tokens. Applying mathematical algorithms to comprehend the context and meaning of the text, it classifies the units of analysis into different sentiments. Asent utilizes a weighted lexicon of word sentiments and uses a rules-based approach to calculate the impact of syntactical variables such as negation and amplifiers.

4.5. Data analysis

4.5.1. Quantitative analyses

Due to the limited sample size and insufficient statistical power for structural equation modeling, we decided to work solely with manifest variables. The statistical analysis was conducted using IBM SPSS Statistics 29. Missing data were handled using multiple imputation (5 imputations) to ensure a more robust analysis. Pooled data was used for subsequent analyses.

To analyze the relationships between teacher educators' confidence in using AI, intrinsic motivation for learning about AI, use of AI for teaching, and their perceptions, Pearson correlation analyses were performed. The significance level was set at .05 for all analyses.

Two mediation analyses were conducted employing the IBM SPSS PROCESS 4.3.1 macro (Hayes, 2022; Model 4). As preliminary diagnostics showed a violation of linearity, the dependent variable (teacher educators' perceptions) was log-transformed to meet the assumption of linearity for regression analysis. Following this procedure, all necessary assumptions (linearity, normality, homoscedasticity, multicollinearity) for mediation analysis were met. Mediation analyses were performed using bootstrapping with 5000 samples to generate 95 % confidence intervals for the indirect effect. The first mediation analysis assessed whether the relationship between teacher educators' intrinsic motivation for learning about AI and their perceptions is mediated by their use of AI for teaching (mediator variable). The second mediation analysis tested whether the association between teacher educators' confidence of using AI and their perceptions is mediated by their use of AI for teaching (mediator variable).

4.5.2. Qualitative analyses

Teacher educators' answers to the open-ended questions, "What do you think about the potential of AI to influence teacher education?" and "What do you think is important for student teachers to understand about AI?", were analyzed thematically following Braun and Clarke (2006, 2020). The thematic analysis was enhanced by incorporating GenAI into the process (Morgan, 2023). Braun and Clarke's reflexive thematic analysis follows a clearly qualitative paradigm and does not aim to quantify qualitative data through a codebook approach or coding reliability, nor does it view such quantification as a meaningful goal (Braun & Clarke, 2020). Instead, reflexive thematic analysis is a "situated interpretative reflexive process" (p. 333) that embraces researcher reflexivity and the co-construction of meaning. However, while the analysis does not rely on counting, the predominance of certain themes holds interpretative value; thus, it is described whether themes were dominant (frequently occurring) or rare (emerging in only a few teacher educator reflections). Furthermore, in reflexive thematic analysis, it is crucial for researchers to provide a detailed account of their reflexive process. Therefore, this process is explicitly described, particularly in relation to the additional GenAI step.

Concerning researcher positionality, the researchers have educational research backgrounds, with particular expertise in teacher education, artificial intelligence in educational settings, and digital technologies. They have either previously or are currently teaching in teacher education programs. This professional experience inevitably shaped their interpretative lens and influenced thematic decisions. At the same time, their familiarity with the field may have introduced implicit assumptions. Therefore GenAI was employed as a tool to uncover potentially overlooked themes and stimulate additional reflection.

4.5.2.1. Procedure. Themes and sub-themes were developed using Braun and Clarke's six-step reflexive thematic analysis procedure. Two of the authors conducted the analysis. First, they read and re-read teacher educators' answers to the questions to gain an initial sense of the data. Second, each author independently generated initial codes and developed preliminary themes and sub-themes, which they then discussed collaboratively. As recommended in reflexive thematic analysis, this dialogue focused on deepening interpretative engagement with the data rather than seeking coding consistency or agreement. Third, the authors used GenAI (for a detailed description see below) to support the identification of additional or overlooked themes. This step aimed to challenge potential blind spots arising from the researchers' own positionality, drawing on prior work suggesting that themes identified by GenAI can lead to deeper engagement with the data (Moorhouse & Kohnke, 2024). Fourth, the authors reviewed and refined the initial themes and sub-themes in light of both the human and GenAI-supported analyses. Fifth, the entire dataset was revisited, with relevant excerpts coded to the agreed (sub-)themes. Sixth, after completing the coding procedure, the authors generated conclusions from the material. The authors presented and defended their individual conclusions and agreed or challenged the conclusions of each other (Peterson & Irving, 2008).

4.5.2.2. GenAI-support of the thematic analysis. The thematic analysis was supported by GenAI. The researchers worked with an Ollama User Interface, hosted through the High Performance Computing Service Ucloud, allowing GDPR-compliant computational services for Danish researchers. The Ollama provided a chatbot interface in which the researchers could interact with the LLM (Llama 3.1 8b model; benchmarked above GPT 3.5-Turbo and slightly below GPT-4o).

In the following the procedure of the first thematic analysis is exemplified (see Fig. 1). The researchers used the GenAI chatbot to identify any themes that were overlooked in the material. In the second step of the thematic analysis, the researchers identified the themes AI literacy, AI didactics, and AI assessment in the material. The researchers

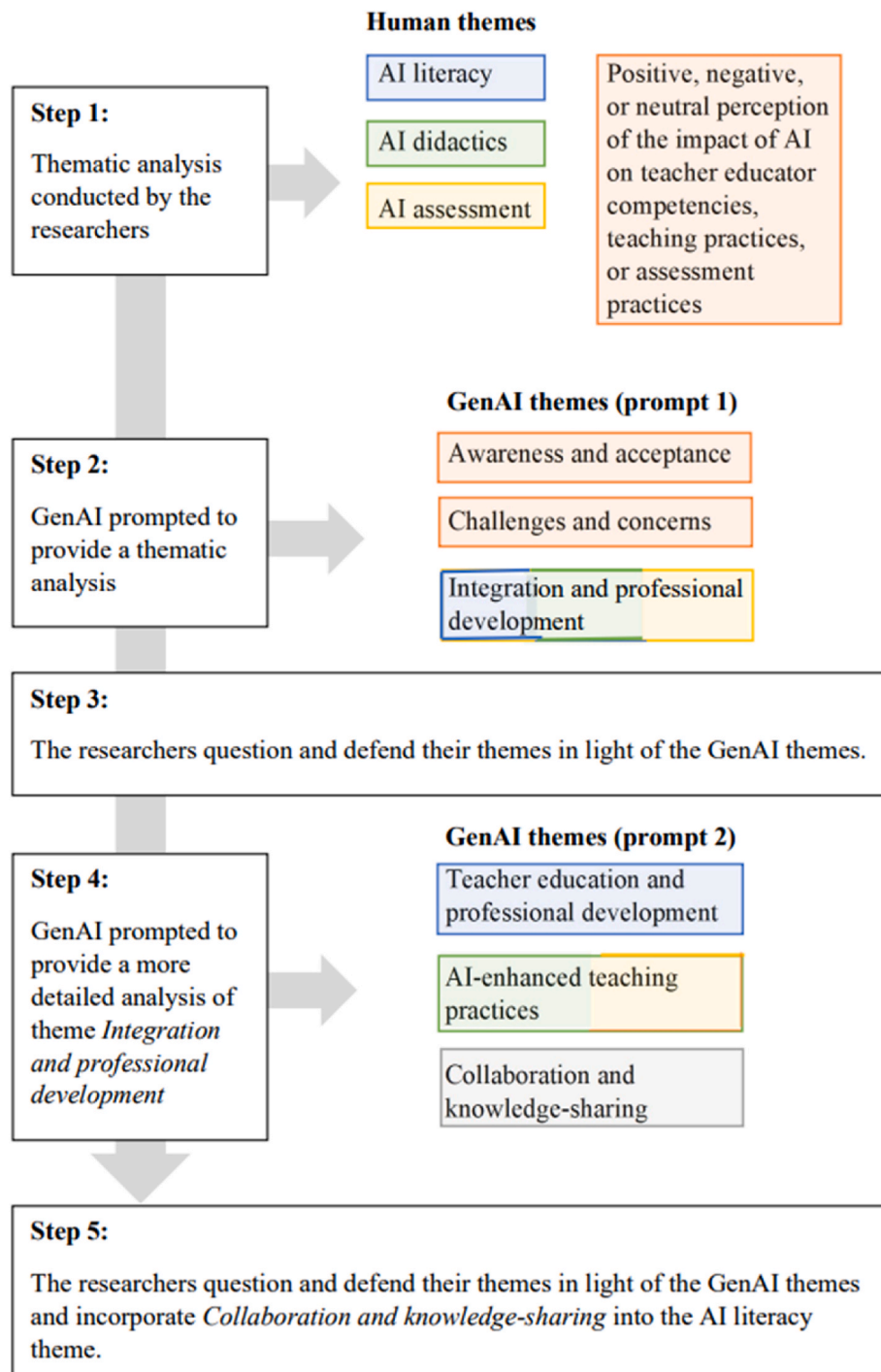


Fig. 1. GenAI-supported process of the first thematic analysis (colors indicate thematic similarity between researcher and GenAI themes).

then prompted the chatbot to analyze the material in the third step: “Use inductive thematic analysis following Braun and Clarke’s (2006) approach. Identify themes in this data set. The data consists of answers to an open-ended survey question posed to teacher educators. The teacher educators were asked: What do you think about the potential of AI for teacher education?” (see Appendix 1 for the GenAI output). As the GenAI themes did not match the researchers’ themes (see Fig. 1), the GenAI themes lead the researchers to reconsider their themes and discuss possible alterations. The GenAI analysis identified overarching valence themes (awareness and acceptance, challenges and concerns) that the researchers perceived as sub-themes of AI literacy, didactics, and assessment. The valence themes could also be expected due to the

phrasing of the open-ended question. Furthermore, it identified the theme integration and professional development, which seemed to combine multiple themes. Therefore, the researchers prompted the chatbot again to produce a more detailed analysis of this theme (prompt: “Theme 3 (Integration and professional development) is very broad. Please analyze if this theme can be divided into more specific themes.”). The second iteration of the GenAI analysis supported the researchers’ initial thematic analysis with the theme AI-enhanced teaching practices combining AI didactics and assessment. The theme teacher education and professional development fit the researchers’ AI literacy theme in scope. After considering the GenAI analysis, the researchers again decided to keep AI assessment a separate theme as teacher educators

indicated more urgency regarding assessment in comparison to didactics. Concerning the researchers' AI literacy theme and the GenAI theme, teacher education and professional development made apparent a difference in focus between the analyses. The GenAI analysis focused on what teacher educators require for AI literacy, while the researchers emphasize AI literacy as a theme with professional development as a supporting factor. However, the GenAI analysis also highlighted collaboration and knowledge-sharing that the researchers had overlooked. Due to the rapid developments in the field of AI, formal professional development may not suffice and make informal collaboration and knowledge-sharing necessary. Therefore, the researchers incorporated this component into the AI literacy theme. Though the GenAI analysis had definite shortcomings by focusing stronger on surface features or providing excerpts that did not fully fit themes it had generated, the researchers considered supporting the thematic analysis with GenAI as extremely beneficial as it forced them to question their themes and defend them in light of the GenAI themes. Hence, this analytical step increases researcher reflexivity by critically engaging with the GenAI themes (Morgan, 2023).

5. Results

Following the research rationale of this study, the results are presented in two parts. First, the quantitative findings focus on mediation analyses examining the contributing factors—intrinsic motivation, confidence, and AI use in teaching—that shape teacher educators' perceptions of AI's potential in teacher education. These results provide a general overview of teacher educators' perceptions and the key factors influencing them. Second, the qualitative findings from reflexive thematic analyses complement these insights by identifying specific areas of teacher education affected by AI and the essential AI knowledge pre-service teachers need to acquire.

5.1. Quantitative analyses

Descriptive statistics and bivariate Person correlations are presented in Table 1. The correlation matrix indicates significant positive correlations between teacher educators' use of AI for teaching and intrinsic motivation, confidence, and perception of the potential of AI, as well as intrinsic motivation and confidence. These results indicate that higher levels on one variable (e.g., intrinsic motivation) correlate with higher levels on another (e.g., confidence).

By conducting mediation analysis, potential indirect effects between variables can be identified. However, it is important to emphasize that, with cross-sectional data, this does not imply causality. The first mediation analysis (see Fig. 2) with intrinsic motivation as independent variable showed that intrinsic motivation significantly predicted teacher educators' use of AI for teaching, with the model accounting for 25.75 % of the variance, $R^2 = .2575$, $F(1,91) = 177.87$, $p < .001$. Intrinsic motivation had a significant positive effect on teacher educators' use of AI, $b = .4817$, $t(91) = 13.34$, $p < .001$, 95 % CI [.4107, .5526]. Teacher educators' use of AI mediated the association between intrinsic motivation and perceptions of the potential of AI. The model explained 7.14 % of the variance, $R^2 = .0714$, $F(2,90) = 19.70$, $p < .001$. While the use of AI had a significant positive effect on perceptions, $b = .0990$, $t(90) =$

5.90, $p < .001$, 95 % CI [.0661, .1320], the direct effect of intrinsic motivation did not reach significance level, $b = .0183$, $t(90) = -1.15$, $p = .25$, 95 % CI [.0496, .0130]. As the indirect effect was significant, $b = .0477$, $BootSE = .0080$, 95 % CI [.0319, .0636], this suggests that intrinsic motivation is indirectly related to teacher educators' perceptions of the potential of AI via increased use of AI for teaching.

The second mediation analysis (see Fig. 3) with confidence of using AI as independent variable showed that confidence significantly predicted use of AI, explaining 20.66 % of the variance, $R^2 = .2066$, $F(1,91) = 133.56$, $p < .001$. Confidence had a significant positive effect on teacher educators' use of AI, $b = .4737$, $t(91) = 11.56$, $p < .001$, 95 % CI [.3932, .5543]. As in the first mediation analysis, teacher educators' use of AI mediated the relationship between confidence and perceptions of the potential of AI. The model accounted for 7.03 % of the variance, $R^2 = .0703$, $F(2,90) = 19.35$, $p < .001$. The direct effect of confidence was not significant, $b = -.0140$, $t(90) = -824$, $p = .41$, 95 % CI [.0472, .0193]. However, the use of AI had a significant positive effect on perceptions, $b = .0953$, $t(90) = 5.87$, $p < .001$, 95 % CI [.0634, .1272]. The significant indirect effect, $b = .0451$, $BootSE = .0079$, 95 % CI [.0300, .0614], suggests that confidence indirectly influences teacher educators' perceptions of the potential of AI through increased use of AI for teaching.

5.2. Qualitative analyses

5.2.1. Perceptions of the potential of AI for teacher education

The first thematic analysis revealed three distinct themes: AI literacy, AI didactics, and AI assessment. In line with the quantitative findings, the qualitative data showed that teacher educators predominantly expressed mixed emotions stating that they were "curious and concerned" or find it "interesting and scary". However, some teacher educators view it clearly negative emphasizing that AI "should be avoided as far as possible" or that they are "concerned about AI's dumbing down of education - that it becomes a 'sausage factory', where AI churns out generic texts, lesson plans, and analyses". On the contrary, some educators show positive anticipation stating that "It will be exciting how AI can support and challenge education". However, teacher educators acknowledge that AI will impact teacher education and, therefore, needs to be thoughtfully implemented or as one educator stated:

AI affects all societal practices, including education and especially teacher education. It is unavoidable and already happening, so for me, the influence is not potential; it is already there. We must be clear about which parts of our profession are essential to "safeguard" from AI and which parts can appropriately meet the profession in particularly planned ways. We must understand AI both as an Ed-tech and as a Tech-ed phenomenon.

Overall, these assertions suggest that teacher educators are still in the early stages of navigating how to integrate AI into teacher education, and that this process is ongoing and evolving.

The thematic analysis reflected this concerning the three themes. Teacher educators perceive different areas of teacher education (literacy, didactics, assessment) impacted to varying degree by AI. Although AI literacy was perceived as a necessary base to adjust teacher education programs to the AI age, it was focused on less than AI didactics and the

Table 1
Means (M), standard deviations (SD) and bivariate Pearson correlations of variables.

	M	SD	1.	2.	3.
1. Intrinsic motivation for learning about AI	3.79	.92			
2. Confidence of using AI	4.17	.84	.60**		
3. Perceptions of the potential of AI for teacher education	.14	.27	.18	.21	
4. Use of AI for teaching	1.92	.87	.51**	.35*	.30**

Note: Intrinsic motivation/confidence of using, Min = 1, Max = 6, perceptions, Min = -1, Max = 1; use of AI, Min = 1, Max = 6, * $p < .01$, ** $p < .001$.

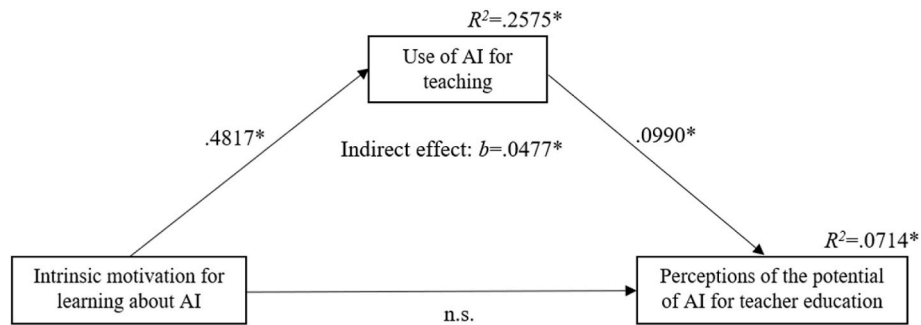


Fig. 2. Standardized regression coefficients for the relationship between intrinsic motivation and teacher educators' perceptions mediated by use of AI. Significant relationships marked with *, n.s. = not significant.

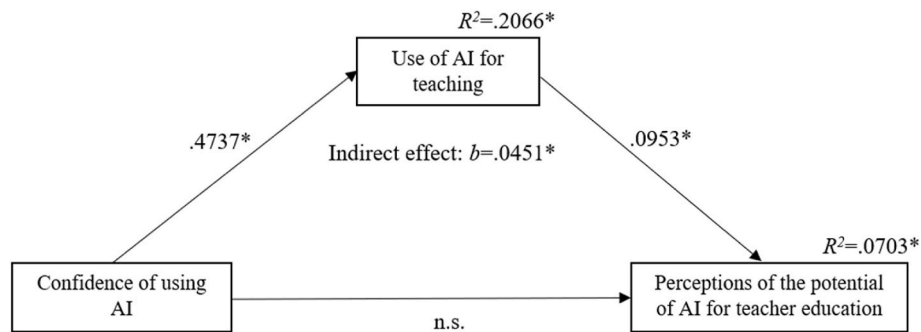


Fig. 3. Standardized regression coefficients for the relationship between confidence and teacher educators' perceptions mediated by use of AI. Significant relationships marked with *, n.s. = not significant.

predominant AI assessment theme. Most teacher educators perceived that they are forced to take AI into account concerning assessment but not necessarily regarding didactics.

5.2.1.1. AI literacy. It became evident from teacher educators' answers that they perceive AI literacy as a central element of future teacher education, both for pre-service teachers and teacher educators. As one teacher educator highlighted, "AI has great potential, and both I and the students need to learn to relate to and use AI where it makes sense. It is necessary to maintain a critical view of AI for both me and my students". The ability to critically interact with AI tools is a common theme across teacher educators' responses and is directly linked to AI didactics. "Integrating AI into education (which I certainly think we should) places great demands on how we organize teaching and learning so that students do not just put a prompt into ChatGPT to answer a teacher-set task. So critical use of AI is essential." Teacher educators also highlighted the need to "collaborate on AI in teacher education" and to "have an open and inclusive culture in teacher education, so we can approach AI critically and share knowledge". Hence, AI tools are constantly evolving making an informal knowledge-sharing culture necessary so that teacher educators stay up to date. A teacher educator also emphasized that pre-service teachers need to be AI literate to responsibly take on their roles as future multipliers of knowledge:

In a democratic society where AI (probably) will play a big role, all elementary school students should learn to interact with AI in a constructive and critical way that supports their deep learning and opportunities to express themselves personally, appropriately, and creatively. This requires teacher students to work critically with the technology - to experience AI's possibilities and limitations.

5.2.1.2. AI didactics. In their responses, teacher educators often touched upon how teacher education needs to rethink its approach to teaching and learning. Teacher educators ascribed AI a transformative power. As one teacher educator highlighted, "People are rushing around and are afraid of cheating in exams, but it requires a completely different focus to educate students". Hence, while the focus for many educators lies on areas such as assessment that are directly affected by the possibilities of AI tools, teacher education will need to adjust as a whole. As one teacher educator states, "There is a great need for us to develop a didactic approach to using AI". However, teacher educators see that AI tools already enable new ways of learning by using them to aid in developing teaching ideas, function as sparring or dialogue partners in planning teaching, or "create learning experiences where teacher students can practice classroom scenarios and gain practical experience in a 'playful' environment". Yet, teacher educators also perceive negative aspects of AI integration. They emphasize that it challenges the traditional understanding of learning and "accelerates the movement away from basic skills". Thus, teacher educators need to develop new ways to ensure basic skills are acquired despite pre-service teachers engaging with AI tools. While most see a need in rethinking teacher education didactics, one teacher educator stated that they "do not think it has much impact yet. It is on the periphery [...]".

5.2.1.3. AI assessment. AI assessment was a dominant theme in teacher educators' reflections. Teacher educators felt strongly about the impact AI has on assessment practices partially questioning the future of written exams entirely. "How should we construct written exams in the future (if we should continue having them at all) so that they are meaningful?" While it is a common theme in teacher educators' responses that they "need to rethink some of the 'old-fashioned' assignment and exam

formats”, two distinct approaches to this process of rethinking can be observed. Some teacher educators consider designing exams in a way that exclude the possibility of AI use or testing pre-service teachers’ knowledge acquisition differently. Others encourage the use of AI and think there is “a need to incorporate it into exams in the future”, possibly as an “active collaborator” in the assessment task.

5.2.2. Teacher educators’ perceptions of essential AI knowledge for pre-service teachers

The second thematic analysis revealed that teacher educators concentrated on two overarching AI literacy domains but also mentioned a third. Dominant themes were AI literacy for teaching with AI tools (*AI as a teaching tool*) and AI literacy for teaching about AI (*AI as teaching content*). A third theme emerged that focuses on pre-service teachers’ requiring AI literacy to anticipate the unintended use of AI tools by students (*AI as a learning tool*). However, this theme was only apparent in few of the teacher educators’ reflections.

In their responses, teacher educators often touched upon that pre-service teachers require knowledge on how AI tools work that enables them to use it for their own teaching but also to teach their students about proper usage. Hence, teacher educators often drew on the interplay between knowledge components concerning AI as a teaching tool, as content, and as a learning tool. This shows how the integration of AI into education differs from most prior technologies. At the same time, teachers need to use it for their own teaching, anticipate student use, and be able to teach about it.

5.2.2.1. AI as a teaching tool and AI as teaching content. First and foremost, teacher educators assessed that technological knowledge about how AI tools work is a prerequisite for technological pedagogical knowledge, i.e., knowledge about how AI tools can support teaching and learning. As one teacher educator emphasized, “My students [pre-service teachers] must understand what AI can do, what it cannot, and how to best use it in their work as teachers.” This involves not only knowledge about the functionality of AI tools and the effective integration into teaching, but also taking the broader societal and democratic context into consideration. Hence, pre-service teachers need to be aware that their use of AI tools in the classroom will also have impact outside the educational sphere.

The interplay of knowledge components in relation to society is, for example, highlighted by a teacher educator writing:

It is most important to understand the challenges that AI brings. It is crucial for future professional bachelor students to understand and take care of what AI can be beneficially used for and what it should not be used for, such as in a learning context. AI will eventually become a democratic issue, and professional bachelors will have significant influence on how this democratic issue is managed in their professions.

Therefore, a large number of teacher educators emphasizes that future teachers require critical thinking skills concerning ethical challenges. As a teacher educator phrases it, “Teacher students should be educated in the ethical use of AI in educational environments, including handling privacy, bias, and security issues.”, pre-service teachers need to develop “a critical-constructive mindset when encountering AI” or be critical and take into account “ethical considerations about its cultural significance”.

When teachers need to educate their students concerning AI, their technological knowledge shifts to content knowledge about AI. This content knowledge is required to guide students to “work creatively and constructively with AI”. As one teacher educator warns, pre-service

teachers will need to “teach students to use it [AI tools] correctly – we must not end up with another ‘digital natives’ fiasco where we fail to address technology and do not provide children with the skills to navigate it”.

However, appropriate integration of AI into teaching does not only require knowledge about AI. Teacher educators also highlighted that strong content knowledge of their teaching subjects is crucial to interact with AI tools and judge the quality of their output. “They have no control over AI’s output – they must always be able to assess it by relying on their professionalism. They must still know all the subject-specific and pedagogical theories and be able to apply them in practice.” Pre-service teachers need to be able to “evaluate whether the output a machine provides is ethically and professionally sound”.

5.2.2.2. AI as a learning tool. Although only few teacher educators touch on it, some emphasize that pre-service teachers require AI literacy because they “will enter a school context where students use AI”. Therefore, they need to be prepared to “navigate a world where students can also use” AI tools. These responses indicate that future teachers need to take into account that students may use AI tools in their school tasks although they were not implemented in the task by the teacher or have not been taught to use and assess the tools by the teacher. Thus, AI literacy is needed to anticipate the unintended or possible use of AI tools by students.

6. Discussion

Lünich et al. (2024) highlight that the successful implementation of AI in education relies significantly on the perceptions and engagement of all stakeholders involved. Teacher educators as multipliers are important stakeholders and accordingly this study explored their perceptions of the potential impact of AI on teacher education and their perceptions of what knowledge pre-service teachers required. Additionally, factors (intrinsic motivation, confidence, use of AI for teaching) contributing to their perceptions of the potential of AI were analyzed. Thematic analysis revealed distinct themes concerning the potential impact (*AI literacy, AI didactics, AI assessment*) and AI literacy domains (*AI as a teaching tool, AI as a learning tool, AI as teaching content*). Furthermore, teacher educators’ use of AI for teaching was a crucial mediating factor in their perceptions of the potential impact of AI.

Concerning the potential impact of AI on teacher education, the results indicate that teacher educators’ views of AI range from extremely negative, to neutral, to positive. This aligns with research showing higher education teachers’ perceptions of the benefits and challenges of AI-based tools for teaching and learning ranging from optimistic, neutral, critically reflective, to critical (Mah & Groß, 2024). However, Mah and Groß (2024) study analyzed higher education teachers’ perceptions across disciplines, while this study focuses on teacher educators. Furthermore, this supports Moorhouse and Kohnke’s (2024) finding that teacher educators in general acknowledge that GenAI will have a significant impact on teacher education.

The mediation analyses revealed that intrinsic motivation and confidence significantly predicted teacher educators’ use of AI for teaching. The use of AI for teaching fully mediated the relationship between intrinsic motivation or confidence and teacher educators’ perceptions. These findings concur with prior research that shows that educators’ attitudes toward AI are influenced by their familiarity with and understanding of its functionalities (Kaplan-Rakowski et al., 2023; Zhai, 2024). Deci and Ryan (2000) underline the importance of intrinsic motivation to foster engagement and curiosity. The results are in line with this, as they show, that educators are more likely to use AI when

they hold more intrinsic motivation for learning about AI. Furthermore, studies show that institutional support and educators' confidence play crucial roles in AI acceptance and integration (Mah & Groß, 2024; Moorhouse & Kohnke, 2024; Ofosu-Ampong, 2024). This study extends these findings, indicating that educators who are confident in using AI tools not only adopt them more readily but also develop a more positive perception of their educational potential. As there is evidence that a lack of knowledge and resources hinders AI integration (McGrath et al., 2023), the findings of this study emphasize that institutions should promote professional development courses concerning AI. Educators who have worked with AI tools often gain practical insights into their capabilities, enabling them to overcome initial concerns (Zimmerman, 2006). Hence, the findings support that professional development courses should offer hands-on experiences in trying out AI tools for classroom practice and at the same time foster teacher educators' intrinsic motivation and enhance their confidence. However, results from the first thematic analysis also indicate that teacher educators' see a need for informal learning opportunities for knowledge-sharing on AI. Building AI literacy in a collaborative manner can serve to mitigate the negative impact of anxiety and discomfort in AI integration and can help teacher educators continuously gain knowledge in a constantly evolving environment (Yang et al., 2025). Overall, the findings from the mediation analyses align with key assumptions of sociocultural learning theory (Vygotsky, 1978) and self-determination theory (Ryan & Deci, 2000). From a sociocultural perspective, the successful implementation of AI in education requires social interaction and collective meaning-making to shape teacher educators' beliefs and knowledge about AI. This collaborative dimension also resonates with self-determination theory, in which a sense of relatedness is crucial for motivation and engagement. In line with SDT, AI integration should therefore be approached as a shared institutional effort including opportunities for professional development to build competence, while also supporting educators' autonomy in how they engage with and apply AI tools.

As teacher educators play a crucial role as multipliers, their perceptions could have significant influence on how future teacher education, and consequently, teaching in schools develops (Korthagen, 2016; Moorhouse & Kohnke, 2024). The thematic analyses revealed what professional development initiatives could focus on to enable teacher educators to take on their role as multipliers responsibly. This study therefore addressed "the urgent need for research that directly addresses teachers' development needs, the barriers they encounter in acquiring AI-related skills, and strategies for overcoming these challenges" (Tan et al., 2025, p. 15). Closing this gap is crucial to enabling teachers to successfully implement AI technologies in education.

In this study, teacher educators saw a need to acquire sufficient knowledge and skills to critically interact with AI tools (*AI literacy*), both for teacher educators and pre-service teachers. This critical stance reflects teacher educators' concerns of the educational and ethical implications voiced by participants in McGrath et al.'s (2023) study but also that teacher educators see how GenAI can enhance educational practices (e.g., Kasneci et al., 2023). It echoes Long and Magerko's (2020) definition of AI literacy as "a set of competencies that enable individuals to critically evaluate AI technologies" (p. 2). As mentioned above, concurring with prior research (Mah & Groß, 2024; McGrath et al., 2023), teacher educators see a need for professional development. Specifically, they see a need for informal forms of professional development, focusing on collaboration and knowledge-sharing, to keep up with the rapid development and changes in the field of GenAI. Hence, research should investigate how teacher educators engage with informal learning opportunities or how such opportunities can be supported, for example, with digital GenAI courses (Mah & Hense, 2021). Concurring

with the literature (e.g., Jensen et al. 2024; Kasneci et al., 2023; Moorhouse & Kohnke, 2024), teacher educators see transformative potential in GenAI integration into their teaching (*AI didactics*) by creating new learning experiences for pre-service teachers. However, they also recognize the need to develop strategies for ensuring basic skills, reflecting concerns about students becoming overly dependent on GenAI tools (Bozkurt et al., 2024; Tlili et al., 2023). Contrary to Moorhouse and Kohnke (2024), teacher educators did not seem fully aware of how their didactical approaches play an important modeling role for pre-service teachers. This may be due to teacher educators perceiving a stronger urgency to reconceptualize assessments. Thus, the modeling effect of teacher educators should be emphasized in professional development initiatives. Regarding assessment (*AI assessment*), two distinct approaches – GenAI inclusion and GenAI exclusion – were identified. Teacher educators seemed to perceive the strongest immediate impact of GenAI in this area. Moorhouse and Kohnke (2024) made similar findings. However, it remains uncertain whether teacher educators have made significant progress in reconceptualizing assessment, as they still appear to lack clear guidelines even two years after the introduction of ChatGPT. Moorhouse and Kohnke (2024) reported this finding for data collected in April 2023, whereas the data collection of the present study occurred a year later. This shows that clear guidelines are required for assessment in the age of artificial intelligence (e.g., Lodge et al., 2023). However, the prevalent focus on assessment and not teaching (*AI didactics*) reveals that teacher educators do not think of teaching and assessment as intertwined. This can lead to teacher educators concentrating too much on assessment, without taking the need to rethink their teaching into account. This could lead to teaching that is detached from students' reality in a world where GenAI is omnipresent. Hence, teacher education institutions need to define when assessment with or without artificial intelligence is applicable (Dawson et al., 2024).

Teacher educators' perceptions of required AI knowledge for pre-service teachers are likely to impact future teacher education curricula and which components concerning AI literacy they will integrate into their teaching. The thematic analysis revealed that teacher educators grasp the complexity of AI literacy for future teachers. Three AI literacy themes emerged: *AI as a teaching tool*, *AI as teaching content*, and *AI as a learning tool*. This triadic perspective highlights the multifaceted challenges pre-service teachers face in the GenAI era (see Fig. 4). Hence, AI literacy is not just teaching-specific but teaching situation-specific.

The individual themes incorporated knowledge components of the TPACK model (Mishra & Koehler, 2006) to different extents. The *AI as a teaching tool* theme mostly reproduces the components of the original TPACK model. By building on technological knowledge, technological pedagogical knowledge, and technological content knowledge, pre-service teachers need to acquire technological pedagogical content knowledge (TPACK) to effectively apply GenAI for teaching purposes. However, the content knowledge component diverges from Mishra and Koehler's original conceptualization by being a necessary prerequisite to judge the quality of GenAI tool outputs. In the context of GenAI, teacher educators also highlighted that pre-service teachers need to be able to master *AI as teaching content*. Hence, the critical-constructive mindset that teachers must develop for effectively using AI as a teaching tool should also be instilled in their students. From this perspective on teachers' AI literacy, technological knowledge shifts to content knowledge. Content knowledge about GenAI becomes the primary focus supported by technological content knowledge and pedagogical content knowledge. The AI literacy focus changes again when *AI is used as a learning tool* by students. From this perspective teachers' pedagogical knowledge becomes most important in combination with technological pedagogical knowledge and pedagogical content knowledge. Given the accessibility, versatility, and widespread use of GenAI, teachers must

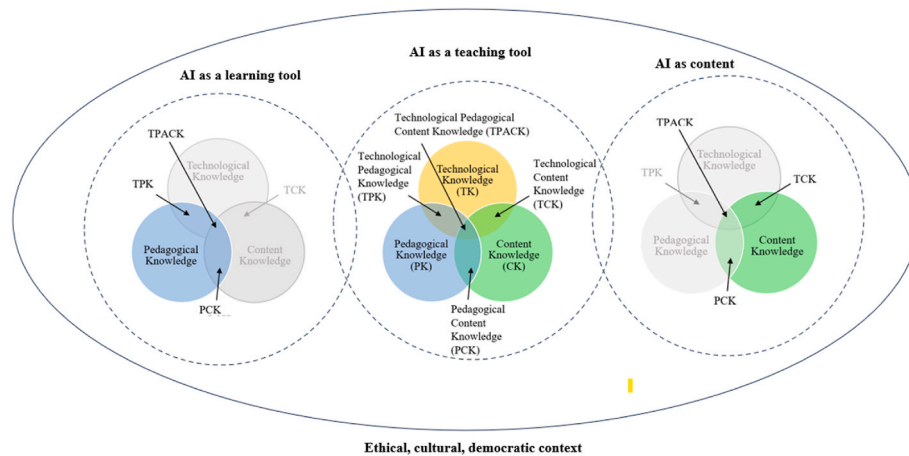


Fig. 4. The triadic nature of AI literacy in the teaching profession. (The original TPACK image was adapted for the figure. Reproduced by permission of the publisher, © 2012 by tpack.org).

anticipate that students may use GenAI tools even when the tasks assigned do not explicitly call for them. Consequently, pre-service teachers need to develop the skills to either design learning environments that render the use of GenAI unnecessary or implement strategies to mitigate potential negative impacts of GenAI use in educational contexts. However, this AI literacy perspective was only mentioned by few teacher educators. Yet, this is an important perspective to take into account and needs to be highlighted for pre-service teachers in professional development courses. Otherwise, this could result in a negative impact at school level, if future teachers believe they do not require any AI literacy because they do not use or teach AI tools themselves (e.g., *AI as a teaching tool*, *AI as content*). The *AI as a learning tool perspective* emphasizes the necessity of AI literacy for all teachers.

All three perspectives on AI literacy in the teaching profession (teaching tool, teaching content, learning tool) are framed by ethical, cultural, democratic context. This extends Celik's (2023b) intelligent TPACK model. While Celik focuses on the ethical dimension, teacher educators additionally highlighted the cultural and democratic dimensions that need to be included in a critical stance on GenAI. Hence, these contextual knowledge components need to guide all GenAI teaching and learning in the classroom. In sum, the findings highlight the complexity of AI literacy in the teaching profession and the necessity to take all perspectives into account to prepare pre-service teachers for the challenges posed by GenAI in education. Traditionally, TPACK has centered on teachers, outlining the types of knowledge they need to integrate educational technologies into their practice. However, the results of this study suggest that this conceptualization requires expansion to integrate student perspectives. This extended understanding of TPACK offers concrete and actionable knowledge domains that teacher educators can address in teacher education. It also highlights which areas of knowledge teacher educators themselves need to acquire, and which topics institutions might target through professional development. A critical addition to this framework is the inclusion of democratic and cultural considerations: teachers must be especially aware of the limitations of AI tools and how their use may impact democracy and cultural norms. While most teacher educators recognize the need for pre-service teachers to acquire AI literacy regarding *AI as a teaching tool* and *content*, AI literacy concerning *AI as a learning tool* must also become a key focus on teacher educators' agenda. Contrary to the UNESCO (2024) competency framework, this especially includes AI literacy to anticipate the unintended use of GenAI tools by students in the learning process.

6.1. Limitations & future research

While this study offers valuable contributions, it also has several limitations that future research should consider. First, the sample size, though representative of all Danish university colleges offering teacher education, was small. Although the response rate of this study is comparable to similar open survey studies (e.g., Byman et al., 2020), response bias might have led to an overrepresentation of educators with strong opinions about AI – whether positive or negative – potentially skewing the results. Second, while the cross-sectional design allows for examining correlations, it inherently limits causal inferences and does not capture changes over time. Nevertheless, at this exploratory stage of educational GenAI research, the research team deems this approach appropriate for providing a broad overview of teacher educators' perceptions, offering valuable baseline insights. Future studies employing longitudinal designs could build on these findings to explore how perceptions of (Gen)AI evolve dynamically over time. Third, the use of broad open-ended questions facilitated the capture of diverse perspectives in the qualitative part of the study. While the research team perceives it a key strength offering a comprehensive understanding of the landscape at this early-stage, future studies could adopt more extensive qualitative approaches (e.g., semi-structured interviews) to explore specific themes in greater depth, even if this requires focusing on a smaller number of educators. The same applies to the selection of quantitative instruments. The research team intentionally focused on teacher educators' use of GenAI tools in their profession; however, their general AI use outside of teaching and their views on technology may also be influential. Therefore, future studies should consider a broader range of variables. Fourth, while a general construct of AI use by teacher educators was applicable for this exploratory study, the findings of this study should be used to develop more fine-grained surveys focusing on different dimensions of AI use by teacher educators (e.g., AI as a teaching tool, AI as a learning tool, AI as content). Fifth, this study was conducted exclusively within Danish teacher education institutions, which operate in a highly digitalized socio-cultural and educational context. While this focus may limit the generalizability of the findings to countries with differing educational systems, it is interesting to note that the results of this study echo the findings from other educational contexts (e.g., general higher education). By addressing these limitations, future research can refine and build on the insights presented, contributing to a deeper and more comprehensive understanding of teacher educators' engagement with AI.

Finally, this study is the first to integrate GenAI into the process of reflexive thematic analysis as an additional step. While the researchers found that the GenAI-assisted analysis provided an additional lens that encouraged critical reflection on their themes (Morgan, 2023), it is essential to emphasize that humans must always remain in the loop. GenAI-generated thematic analysis is shaped by the underlying model architecture, its training data, and the prompts used. Reflexive thematic analysis does not seek objectivity but derives its rigor from the researcher's transparent and reflective engagement with the data. While GenAI tools can identify patterns in data, they do not engage with the data reflexively. Hence, there is a risk that thematic analyses generated by GenAI result in superficial topic summaries that lack the depth, theoretical grounding, and domain-specific knowledge applied by researchers when engaging directly with the data. In addition to maintaining a critical awareness of the biases embedded in GenAI tools, researchers must also remain vigilant about potential hallucinations, i. e., plausible-sounding yet incorrect outputs. To mitigate these risks, GenAI should only be employed after an initial human thematic analysis has been conducted, as in the present study. This ensures that GenAI is used as a tool to support and deepen researchers' reflective processes, but not as a substitute for their thematic analysis.

Methodologically, researchers are encouraged to include the prompts and GenAI-generated outputs as part of their publications to enhance transparency and replicability. While this study only used very simple prompts, future research could explore how more extensive pre-prompting, for example, assigning the GenAI tool a researcher persona with a defined theoretical stance, might deepen engagement with GenAI-generated thematic analyses and enhance researchers' reflective processes. Overall, these considerations highlight the need for future research into both the opportunities and limitations of GenAI tools in the context of reflexive thematic analysis.

6.2. Conclusion

This study contributes to the understanding of teacher educators' perceptions of AI in education. It employed a mixed-method design including the use of GenAI-enhanced thematic analysis to investigate the perceptions of teacher educators. The research team found that incorporating AI enhanced support was beneficial in terms of encouraging self-reflection on the analysis results. However, it is essential to note that AI-enhanced methods should be used as a supplementary tool, rather than as a substitute for the expertise of researchers (Park et al., 2024; Ullman, 2023).

The findings highlight the diverse perceptions of teacher educators on GenAI, ranging from enthusiasm for its transformative potential to apprehension regarding its challenges and implications. The findings align with prior research, highlighting the need to build teacher educators' AI literacy (e.g., McGrath et al., 2023; Moorhouse & Kohnke, 2024). The mediation analyses revealed the importance of teacher educators' personal use of GenAI in teaching. Therefore, teacher education institutions should focus on professional development courses that offer hands-on experiences with AI tools (Rampelt et al., 2025). However, beyond formal training, teacher education institutions must also explore strategies to implement informal, collaborative knowledge-sharing

opportunities. These are necessary for continuously fostering critical, ethical, and reflective engagement with GenAI (AI literacy). The findings further indicate that teacher educators recognize GenAI's potential to transform teaching practices (AI didactics) by creating innovative learning opportunities. However, they also emphasize the importance of safeguarding basic skill acquisition. Furthermore, the urgent need to reconceptualize assessments emerged as a key theme (AI assessment). Hence, teacher education institutions need to provide clear guidelines for the use of GenAI in assessments to prevent a disconnect between teaching practices and the learning realities of students in the GenAI-era (Dawson et al., 2024; Lodge et al., 2023).

Finally, this study emphasizes the multifaceted nature of AI literacy. Extending on the conceptualizations of Mishra and Koehler (2006) and Celik (2023b), teacher educators indicated that pre-service teachers need to acquire multiple AI literacies –AI as a teaching tool, AI as content, and AI as a learning tool– all framed within ethical, cultural, democratic boundaries. Especially the possibly unintended use of GenAI by students highlights the necessity of AI literacy for all teachers, regardless of their willingness to implement GenAI in their classrooms. By addressing these interconnected dimensions, institutions can prepare both teacher educators and pre-service teachers to critically and confidently engage with GenAI, ensuring its integration aligns with educational and societal values (Bećirović & Mattoš, 2024; Ifenthaler et al., 2024).

CRedit authorship contribution statement

Christopher Neil Prilop: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Dana-Kristin Mah:** Writing – original draft, Methodology, Conceptualization. **Lucas Jasper Jacobsen:** Writing – original draft, Methodology. **Rasmus R. Hansen:** Writing – original draft, Methodology, Formal analysis. **Kira Elena Weber:** Writing – original draft, Conceptualization. **Fabian Hoya:** Writing – original draft, Conceptualization.

Statement on ethics and open data

The study was approved by an ethical committee with ID: BSS-2024-066-A. Informed consent was obtained from all participants, and their privacy rights were strictly observed. The authors do not have permission to share data.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT 4o in order to improve readability and language of the work. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

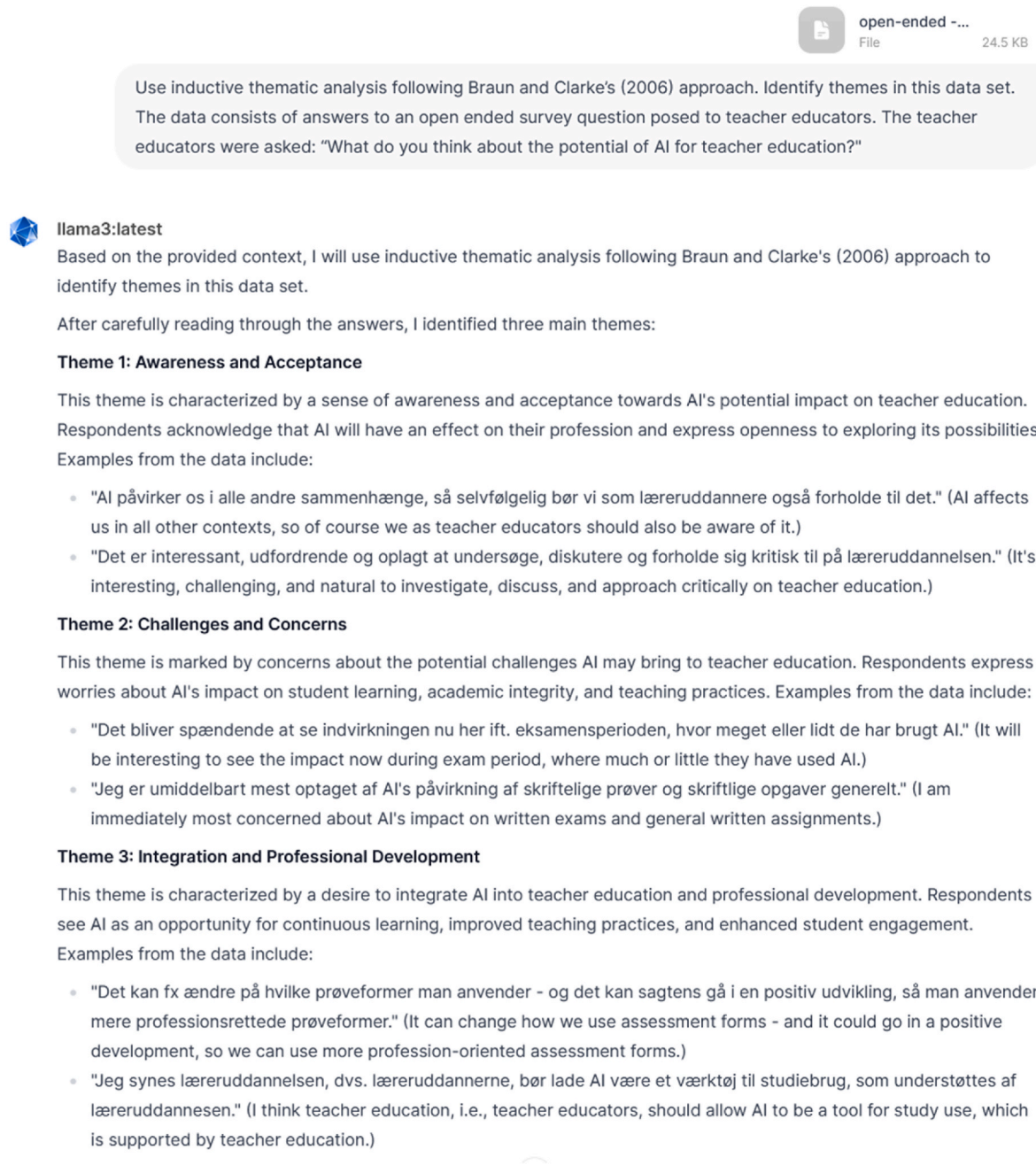
Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1

Thematic analysis 1

Screenshot of the GenAI interaction



The screenshot shows a file upload interface with a file named "open-ended -..." (24.5 KB). Below the file is a text box containing the prompt: "Use inductive thematic analysis following Braun and Clarke's (2006) approach. Identify themes in this data set. The data consists of answers to an open ended survey question posed to teacher educators. The teacher educators were asked: 'What do you think about the potential of AI for teacher education?'".

The response from llama3:latest is as follows:

Based on the provided context, I will use inductive thematic analysis following Braun and Clarke's (2006) approach to identify themes in this data set.

After carefully reading through the answers, I identified three main themes:

Theme 1: Awareness and Acceptance

This theme is characterized by a sense of awareness and acceptance towards AI's potential impact on teacher education. Respondents acknowledge that AI will have an effect on their profession and express openness to exploring its possibilities. Examples from the data include:

- "AI påvirker os i alle andre sammenhænge, så selvfølgelig bør vi som læreruddannere også forholde til det." (AI affects us in all other contexts, so of course we as teacher educators should also be aware of it.)
- "Det er interessant, udfordrende og oplagt at undersøge, diskutere og forholde sig kritisk til på læreruddannelsen." (It's interesting, challenging, and natural to investigate, discuss, and approach critically on teacher education.)

Theme 2: Challenges and Concerns

This theme is marked by concerns about the potential challenges AI may bring to teacher education. Respondents express worries about AI's impact on student learning, academic integrity, and teaching practices. Examples from the data include:

- "Det bliver spændende at se indvirkningen nu her ift. eksamensperioden, hvor meget eller lidt de har brugt AI." (It will be interesting to see the impact now during exam period, where much or little they have used AI.)
- "Jeg er umiddelbart mest optaget af AI's påvirkning af skriftelige prøver og skriftlige opgaver generelt." (I am immediately most concerned about AI's impact on written exams and general written assignments.)

Theme 3: Integration and Professional Development

This theme is characterized by a desire to integrate AI into teacher education and professional development. Respondents see AI as an opportunity for continuous learning, improved teaching practices, and enhanced student engagement. Examples from the data include:

- "Det kan fx ændre på hvilke prøveformer man anvender - og det kan sagtens gå i en positiv udvikling, så man anvender mere professionsrettede prøveformer." (It can change how we use assessment forms - and it could go in a positive development, so we can use more profession-oriented assessment forms.)
- "Jeg synes læreruddannelsen, dvs. læreruddannerne, bør lade AI være et værktøj til studiebrug, som understøttes af læreruddannelsen." (I think teacher education, i.e., teacher educators, should allow AI to be a tool for study use, which is supported by teacher education.)

Output:

Prompt 1:

Use inductive thematic analysis following [Braun and Clarke's \(2006\)](#) approach. Identify themes in this data set. The data consists of answers to an open ended survey question posed to teacher educators. The teacher educators were asked: "What do you think about the potential of AI for teacher education?"

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This theme is characterized by a desire to integrate AI into teacher education and professional development. Respondents see AI as an opportunity for continuous learning, improved teaching practices, and enhanced student engagement. Examples from the data include.

- "Det kan fx ændre på hvilke prøveformer man anvender - og det kan sagtens gå i en positiv udvikling, så man anvender mere professionsrettede prøveformer." (It can change how we use assessment forms - and it could go in a positive development, so we can use more profession-oriented assessment forms.)
- "Jeg synes læreruddannelsen, dvs. læreruddannerne, bør lade AI være et værktøj til studiebrug, som understøttes af læreruddannelsen." (I think teacher education, i.e., teacher educators, should allow AI to be a tool for study use, which is supported by teacher education.)

These three themes provide a comprehensive overview of the responses from the teacher educators regarding the potential of AI for teacher education.

We identified the overall themes: AI literacy: Students and teachers knowledge and understanding of AI AI didactics: The practice of teaching and learning with the emergence of AI in mind Assessment: The change that AI imposes on exams.

Can you identify something that we have missed, that does not work within the three overall themes?

Prompt 2:

Your theme 3 (Integration and Professional Development), is very broad. Please analyze if this theme can be sub-divided into more specific themes. llama3:latest.

I'm glad you brought this up!

After re-analyzing the data, I think that Theme 3 (Integration and Professional Development) can indeed be further sub-divided into more specific themes. Here's a possible breakdown.

Sub-theme 1: AI-enhanced Teaching Practices

- Examples from the data include:
 - o "Det kan fx ændre på hvilke prøveformer man anvender – og det kan sagtens gå i en positiv udvikling, så man anvender mere professionsrettede prøveformer." (It can change how we use assessment forms – and it could go in a positive development, so we can use more profession-oriented assessment forms.)
 - o "Jeg synes læreruddannelsen, dvs. læreruddannerne, bør lade AI være et værktøj til studiebrug, som understøttes af læreruddannelsen." (I think teacher education, i.e., teacher educators, should allow AI to be a tool for study use, which is supported by teacher education.)

This sub-theme explores the potential of AI to enhance teaching practices and improve student learning outcomes.

Sub-theme 2: Teacher Education and Professional Development

- Examples from the data include:
 - o "Det er vigtigt at have en åben og inkluderende kultur i læreruddannelsen, så man kan forholde sig kritisk til AI." (It's important to have an open and inclusive culture in teacher education, so we can approach AI critically.)
 - o "Jeg tror, det er vigtigt at se på, hvordan vi kan bruge AI i læreruddannelsen, så vi kan give studerende en bedre forståelse af, hvad AI er og hvordan de kan bruge det." (I think it's important to look at how we can use AI in teacher education, so we can give students a better understanding of what AI is and how they can use it.)

This sub-theme focuses on the importance of incorporating AI into teacher education and professional development programs.

Sub-theme 3: Collaboration and Knowledge Sharing

- Examples from the data include:
 - o“Jeg tror, det er vigtigt at se på, hvordan vi kan samarbejde omkring AI i læreruddannelsen.” (I think it’s important to look at how we can collaborate on AI in teacher education.)
 - o“Det er vigtigt at have en åben og inkluderende kultur i læreruddannelsen, så man kan forholde sig kritisk til AI og dele viden omkring AI.” (It’s important to have an open and inclusive culture in teacher education, so we can approach AI critically and share knowledge about AI.)

This sub-theme highlights the importance of collaboration, communication, and knowledge sharing among teachers, educators, and other stakeholders when it comes to integrating AI into educational settings.

Please let me know if you’d like me to further refine these sub-themes or explore any other aspects of this theme!

Appendix 2

English version of the scale:

In the context of my teaching, I use AI ...

(Scale: Not at all, Very rarely, Rarely, Occasionally, Frequently, Very frequently).

For planning small class teaching.

For planning lectures.

For creating teaching materials for myself.

For creating learning materials for students.

For creating exam questions/tests.

For evaluating exams.

For recommendations for relevant teaching materials.

For creating presentations.

To generate feedback for students.

Creation of materials.

For research.

Danish version of the scale:

I min undervisning bruger jeg AI ...

(Skala: Slet ikke, Meget sjældent, Sjældent, Lejlighedsvist, Ofte, Meget ofte).

Til planlægning af holdundervisning

Til planlægning af forelæsninger.

Til at skabe undervisningsmaterialer til mig selv

Til at skabe læringsmaterialer til studerende.

Til at skabe eksamensspørgsmål/tests.

Til evaluering af eksamener

Til anbefalinger af relevante undervisningsmaterialer.

Til at skabe præsentationer.

Til at generere feedback til studerende.

Til skabelse af materialer

Til forskning

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