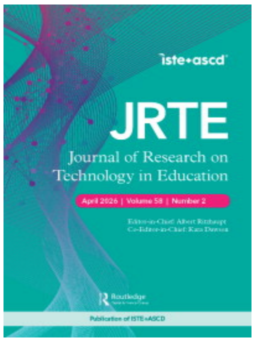

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School teachers in Germany and Denmark: a comparative study of self-efficacy and distinct profiles in using Artificial Intelligence for teaching and learning

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ABSTRACT

This paper provides insights into the perspectives of school teachers ($N=532$) on the subject of Artificial Intelligence (AI) in Germany ($n=256$) and Denmark ($n=276$), focusing on their perceptions, AI self-efficacy, and distinct teacher profiles. Teachers in Germany recognized the usefulness of AI tools for individualized learning more strongly than teachers in Denmark. Furthermore, teachers in Germany consistently reported higher levels of AI self-efficacy. Latent class analysis yielded four distinct school teacher profiles: (rather) optimistic, (rather) critical, critically reflected, and ambiguous. These profiles exhibited differences among teachers in Germany and Denmark. The findings indicate that the educational systems impact teachers' perceptions and AI self-efficacy differently, which needs to be considered for targeted interventions. The distinct teacher profiles provide an opportunity to develop tailored interventions to ensure responsible adoption.

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Artificial intelligence; teachers; Germany; Denmark; AI self-efficacy; latent profile analysis

Introduction

Emerging research suggests that students' use of artificial intelligence (AI) tools in schools ranges from extensive use for most tasks to complete nonuse (Dalsgaard & Prilop, 2025; Stanford University, 2024). While both extremes are unsustainable, educational stakeholders agree that acquiring AI literacy is crucial to students' future success and should be actively fostered by teachers in school (OECD, 2025; UNESCO, 2024a; Wang & Lester, 2023). Consequently, teachers need to integrate AI in their teaching practice. Research on educational technology adoption (Granić, 2022) has identified key factors influencing teachers' use of technologies in the classroom, with teachers' self-efficacy emerging as a decisive predictor. This is supported by recent studies with student teachers that suggest that student teachers use of AI is predicted by factors such as AI self-efficacy (Hoya et al., 2024; Ma & Lei, 2024). However, research specifically examining school teachers' AI self-efficacy is lacking and on their perspectives on AI for teaching and learning remains limited (Antonenko & Abramowitz, 2023; Zhai, 2024). Given the crucial role of teachers in implementing AI in their teaching and fostering students' responsible engagement with AI, a more comprehensive understanding of teachers' preparedness and perspectives is needed (Celik et al., 2022; Mishra et al., 2024).

Comparisons of teachers' perspectives on AI across different countries can provide valuable insights. Neighboring countries such as Denmark and Germany, which share similar socio-economic

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indicators yet differ markedly in educational technology adoption policies and practices, present insightful comparative cases. Denmark and Germany's differences in educational technology adoption are evident in the results of the International Computer and Information Literacy Study (ICILS) and can be attributed to Denmark's long-term strategic policies promoting digital literacy since the 1990s (e.g. Nielsen, 2005). For instance, Denmark has consistently outperformed Germany in digital literacy, as shown in both ICILS 2018 and 2023 (Fraillon, 2024; Fraillon et al., 2020). Digital literacy (which encompasses the safe, critical, and responsible use of and engagement with digital technologies for education, training, work, and participation in society) is perceived as a key prerequisite for the development of AI literacy (European Commission, 2019). Given the high level of digitalization in Denmark's school system, it raises the question whether this advantage is also reflected in the context of generative AI technologies concerning teacher's preparedness and perspectives.

In light of the distinct differences between Denmark and Germany, this study compares Danish and German teachers' perspectives on AI and their AI self-efficacy. Contrasting teachers from Denmark's highly digitized educational system with those from Germany, a school system that performs at an average level in terms of digitalization, offers first insights into the factors that may promote teachers' meaningful and competent use of AI in schools.

Theoretical background

Artificial Intelligence in education

The rise of generative AI (genAI) has led to international discussions concerning its potential benefits, challenges, and implications for education (Bozkurt et al., 2024; Crompton & Burke, 2024). In a systematic review, Celik et al. (2022) focused on the promises and challenges of AI for teachers. The results indicated three categories of AI advantages for teachers: planning (e.g. identifying the needs of students and planning activities), implementation (e.g. timely monitoring and immediate feedback), and assessment (e.g. automated assessments and evaluations, as well as feedback on the effectiveness of instructional practices). The study also indicated challenges in AI use, such as the limited reliability of AI algorithms, limited technical capacity of AI, limited technical infrastructure in schools for AI, lack of teacher technological knowledge on AI use, and lack of teacher interest in AI.

Other studies have discussed AI use and academic integrity (Cotton et al., 2024), alternative forms of assessment (Hodges & Kirschner, 2024; Moorhouse et al., 2023), and implications of instructional design and models on technological, pedagogical, and content knowledge (TPACK) (Petko et al., 2025), curriculum development (UNESCO, 2022), and AI literacy (Long & Magerko, 2020; Ng et al., 2022; UNESCO, 2024a, 2024b). With respect to the adoption of technology in the context of teaching and learning, recent discourse has focused on modifying and extending established frameworks such as TPACK (Mishra & Koehler, 2008) to incorporate AI components, such as ethical considerations and contextual knowledge (Brianza et al., 2024; Celik, 2023) or the triadic nature of AI literacy required (AI as a teaching tool, AI as a learning tool, AI as teaching content) (Prilop et al., 2005). Furthermore, extensions of models of technology acceptance, such as the Technology Acceptance Model (Davis et al., 1989) and the Unified Theory of Acceptance and Use of Technology (Kelly et al., 2023; Venkatesh et al., 2003) provide insights into which factors influence AI adoption. Research on educational technology adoption prior to the emergence of ChatGPT indicated that teachers' self-efficacy is a crucial predictor of technology use in classrooms (Granić, 2022). Recent studies show similar findings for student teachers in the context of AI (Mah & Groß, 2024). Yet, to our knowledge, studies have not focused on in-service teachers regarding self-efficacy. Moreover, current research emphasizes the importance of attitudes toward AI. For example, Delcker et al. (2024) found that attitudes significantly explain the intended use of AI tools. In the context of AI literacy, numerous frameworks have been developed with the aim of defining the necessary competencies for teachers and students in the era of AI. For instance, the United Nations Educational, Scientific and Cultural Organization (UNESCO) developed one such framework (OECD, 2025; UNESCO, 2024a, 2024b). To a limited extent, research has been conducted on topics such as teachers' perceptions of utilizing AI and differences in teachers' AI self-efficacy for teaching and learning in school.

Drawing from the extant literature on general self-efficacy, which Bandura (1991) defined as "people's beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives" (p. 257) and which is domain-specific (Bandura, 1994), specific forms of self-efficacy can be distinguished. For example, there is technology self-efficacy for interacting with technology (Kraus et al., 2021) and AI self-efficacy, which Wang and Chuang (2024) defined as "individuals' general belief in their ability to use and interact with AI." (p. 4789). In the context of education, Bewersdorff et al. (2025) defined AI self-efficacy as "students' confidence in their capabilities to use and interact but also to understand and learn about AI technologies and applications." (p. 2). To date, a limited number of studies have examined the concept of AI self-efficacy. The available research suggests an interplay between AI self-efficacy, use, attitudes (e.g. positive and negatives attitudes toward AI), interest, and literacy (Bewersdorff et al., 2025; Knoth et al., 2024). Accordingly, there is a need to better understand AI literacy and AI self-efficacy and to develop scales to measure these rather emergent constructs (Bewersdorff et al., 2025; Chiu, Ahmad, et al., 2025; Chiu, Çoban, et al., 2025; Hornberger et al., 2023; Mah & Groß, 2024; Wang & Chuang, 2024).

Furthermore, there is a need for additional studies comparing teachers' perspectives on AI in different countries. Recent research on AI in education has been predominantly conducted in the United States and China (Mustafa et al., 2024), with limited research conducted in Europe. Nevertheless, further research on AI in K-12 education throughout Europe is warranted, for example in light of the political context, such as the EU AI Act and the General Data Protection Regulation (European Union, 2016, 2024), to acquire insight into the European perspective and practice.

Germany and Denmark: digital transformation and AI in schools

Factors such as comparable socio-economic indicators and geographical proximity make Germany and Denmark valuable comparative cases for investigating how teachers' perspectives on AI in teaching and learning differ or align. Especially Germany and Denmark's distinct policies and practices regarding educational technology adoption can shed light on which factors may influence AI adoption in schools. The International Computer and Information Literacy Study (ICILS) provides some insights of the degree of educational technology adoption in Denmark and Germany. Regarding computer and information literacy, the score across participating countries was 476 scale points in the ICILS 2023, while Denmark achieved the third-highest score at 518. In computational thinking, the average score was 483 scale points, with Denmark significantly exceeding this average and ranking fifth with 504 points. In contrast, Germany scored 479 scale points in computational thinking (Fraillon, 2024). As these skills can be seen as prerequisites of AI literacy (European Commission, 2019), this study will be able to provide an indication what role long- and short-term digitization policies play concerning AI in schools. As a basis, it is important to understand which role AI and digitization strategies played in the past and play currently in Germany and Denmark.

The German education system has been slow to adopt to educational technologies and until the COVID-19 pandemic seemed "to be lagging in the use of digital technology for teaching and learning" (Kerres, 2020; p. 690). To a large extent, this can be based on prominent publications in the educational field that describe digital technologies as detrimental to students' learning and well-being or are highly skeptical about the need for technology in the classroom (Spitzer, 2012; von Hentig, 2003) but also strict data security laws that limit teachers' use of digital tools (Kerres, 2020). Still, Germany has undertaken efforts to incorporate educational technology into schools in the last 10 years. A national strategy focusing on education in the digital world was developed in 2016 in response to the digital transformation (Kultusministerkonferenz, 2016). An updated version was published in 2021, which includes additional aspects of teaching and learning in the digital age (Kultusministerkonferenz, 2021). Furthermore, the German government invested 6.5 billion euros in a digital infrastructure program for schools (DigitalPakt Schule, 2019–2024) to provide schools with better information and communications technology (ICT) equipment and technical support (Bundesministerium für Bildung, 2024). With a focus on AI, the Standing Conference of the Ministers of Education and Cultural Affairs (Kultusministerkonferenz, KMK) published recommendations for the administration concerning the integration of AI into educational processes (Kultusministerkonferenz, 2024). Furthermore, the Standing Scientific Commission on Educational Policy (Ständige Wissenschaftliche Kommission, SWK), which is an independent scientific advisory board of the KMK, published a discussion paper on the potential of large language models (LLMs) for the education system (SWK, 2024). For example, the SWK proposed a transition phase to systematically test LLMs with an open mindset, using LLMs from secondary school on, and to create the necessary environment by including access to LLMs (ideally open-source), alternative exams, and opportunities to develop AI literacy (SWK, 2024).

Furthermore, many federal states in Germany have developed separate guidelines and recommendations regarding the utilization of AI in educational institutions (Schulministerium NRW, 2023; Stoppe, 2023). Studies on the utilization of AI by teachers and students in schools (Bitkom, 2024; Vodafone Stiftung, 2024) suggest that approximately half have already employed AI-based tools, particularly ChatGPT (Bitkom, 2024). Additionally, the number of German states offering AI-based tools for teachers and students in schools has been increasing, with the objective of aligning with the General Data Protection Regulation (GDPR) established by the European Union (Limpert, 2025).

In Denmark, there have been continuous political initiatives concerning digitalization in schools, particularly primary schools, since the mid-1990s. In the late 1990s, the Ministry of Education developed the Pedagogical IT Driver's License program as a course offered to all primary school teachers to develop their pedagogical IT skills. This initiative was joined by the 3-year IT, Media and the Public School project (with a budget of approximately 45 million euros) that focused on increasing the use of technology in schools (Nielsen, 2005). A follow-up project entitled IT in the Public School, directed primarily at digital infrastructure and materials, ran from 2004 to 2008 with a total budget of approximately 70 million euros (Danish Government, 2003). In the late 1990s, some schools implemented the portal SkoleIntra, providing digital infrastructure for internal and external communication. In 2019, SkoleIntra was replaced by Aula, a new national portal for all primary schools in Denmark. The most recent national digitalization strategies are from 2019 and 2022, with the latter investing approximately 30 million euros to implement technology for the primary education context (Ministry of Children and Education, 2019; Ministry of Finance, 2022). In recent years, there has been an increased focus on digital competence, both in upper secondary education (Danish Government, 2016) and primary education (Ministry of Children and Education, 2021). With the current government, there has been a slight shift toward a more hesitant and reluctant view on digital technologies in education, focusing more on the "analog" and moving away from digital technologies. For instance, there is currently political talk of banning mobile phones in schools and balancing the use of digital technologies with analog activities (Ministry of Children and Education, 2024). However, recently, the Ministry of Children and Education developed guidelines for the use of genAI in primary and upper secondary school (Expert group On ChatGPT And Other Digital Aids, 2024; Ministry of Children and Education, 2024). The primary recommendation for schools is to develop common guidelines for all teachers, and schools are encouraged by policymakers to invite genAI into the classroom and to teach pupils how to use genAI.

Germany and Denmark exhibit clear differences in how and when educational technology adoption progressed. While continuous political initiatives have positioned Denmark as a frontrunner in educational technology adoption, the German education system experienced a major boost in the integration of technology only during the COVID-19 pandemic (Kerres, 2020). In Germany, technology was long perceived as potentially detrimental to students' academic development, was often met with skepticism, due to influential publications (Spitzer, 2012; von Hentig, 2003) or limited by strict data security regulations (Kerres, 2020). However, since the pandemic and particularly the emergence of genAI, Germany has been investing more into and promoting the use of educational technologies. This is especially the case for AI. For example, the Standing Scientific Commission on Educational Policy recommended testing LLMs with an open mindset and a variety of states in Germany actively support AI adoption by providing their teachers and students with AI-based tools (Limpert, 2025; SWK, 2024). In contrast, Denmark seems to be undergoing a shift toward a more hesitant and reluctant stance on digital technologies in education (Ministry of Children and Education, 2024). Yet, the fact that only about half of all teachers in Germany have used genAI for educational purposes (Bitkom, 2024) suggests that German teachers are still skeptical toward educational technologies (Eickelmann et al., 2024).

Research questions

Building on this theoretical background, this study compares teachers in a highly digitized education system, such as Denmark, with teachers in a system characterized by average levels of digitalization, such as Germany, and addresses the following research questions:

1. What are teachers' perceptions of utilizing AI for teaching and learning in schools? Are there significant differences between Germany and Denmark?
2. Are there significant differences in teachers' AI self-efficacy for teaching and learning in schools based on country (Germany/Denmark)?
3. What distinct teacher profiles can be identified through latent class analysis (LCA) of the perceived benefits and challenges of AI-based tools for teaching and learning with regard to (a) all participating teachers, (b) teachers in Germany, and (c) teachers in Denmark?

Method

Data collection and participants

An online questionnaire was designed to collect data from teachers in Germany and Denmark. Data were gathered from January to February 2025 by a market research institute (Norstat) that organized the recruitment of participants and the provision of the online questionnaires. The online questionnaires were provided in German for the teachers in Germany and in Danish for the teachers in Denmark. In total, $N = 532$ teachers participated in this study (256 from Germany and 276 from Denmark). Regarding the participants from Germany, 22.4% were teachers at ISCED level 1 (primary schools), 63.7% at a different ISCED level (secondary schools), and 13.9% at another school type (UNESCO Institute for Statistics, 2012). Of the participants in Denmark, 60.3% were teachers at Fokeskole (primary schools), 14.1% Privatskole/Friskole (either primary or secondary schools), 4.2% Efterskole, 8.4% Gynmasium (secondary school), and 13% other school types. The three subjects taught most frequently were native language (German/Danish) (40.8%), mathematics (28.8%), and second language (28.8%) (multiple answers possible). Table 1 presents the sample description.

Instrument

To address the research questions that guided this study, the following items were selected from our online questionnaire, which was adapted from existing literature. The survey inquired about respondents' gender, age, main subjects, and school type.

Table 1. Sample description.

Variable	Total		Germany		Denmark	
	N	%	*n*	%	*n*	%
Participants	507		245		262	
Female	293	57.8	147	60.0	146	55.7
Male	213	42.0	98	40.0	115	43.9
Diverse	1	0.2	—	—	1	0.4
Age						
≤29 years	35	6.9	18	7.3	17	6.5
30–49 years	244	48.1	132	53.9	112	42.7
50–59 years	131	25.8	54	22.0	77	29.4
≥ 60 years	97	19.1	41	16.7	56	21.4

Note. $N = 532$; $n = 25$ missing data for gender and age.

Teachers' use and perceptions of AI-based tools

We adapted different items from ICILS 2023 (Fraillon & Rožman, 2024) to assess teachers' use of AI-based tools for their teaching (e.g. "How often do you use AI in these settings?") and their perceptions of AI-based tools for students' learning (e.g. "Using AI-based tools at school helps students develop a greater interest in learning" and "Using AI-based tools in school distracts students from learning"). Furthermore, we adapted three items from ICILS 2023 regarding statements on teacher collaboration and discussion in the context of AI-based tools (e.g. "I collaborate with other teachers on improving the use of AI in classroom teaching"; 1 = strongly agree, 4 = strongly disagree; α = .85).

Teacher AI competence self-efficacy scale (TAICS scale)

We used Chiu, Ahmad, et al. (2025) scale to measure teachers' AI competence and self-efficacy (TAICS scale). The TAICS scale comprises six dimensions: AI knowledge (AIK) (e.g. "I can distinguish whether a tool is AI-based or not") (α = .79), AI pedagogy (AIP) (e.g. "I can choose an AI tool to use in my classroom that enhances what I teach, how I teach, and what students learn") (α = .92), AI assessments (AIA) (e.g. "I can design an assessment approach to improve student learning in an AI-based environment, such as learning with ChatGPT") (α = .92), AI ethics (AIE) (e.g. "I teach students how to behave safely and responsibly when learning with AI tools") (α = .73), human-centered education (HCE) (e.g. "I can assess the benefits of an AI tool" and "I can assess the risks of an AI tool.") (α = .83), and professional engagement (PEN) (e.g. "I actively share my AI teaching experience with other colleagues within and outside my educational organization") (α = .84). Each dimension includes four items (except for AI ethics, which includes three items) assessed on a 5-point Likert scale from 1 = strongly disagree to 5 = strongly agree.

Data analysis

Descriptive statistics and data preparation for multivariate analyses were carried out using IBM SPSS 29 (New York) software (IBM Corporation, 2024). To determine the differences between two groups (RQ1 and RQ2), independent t-tests were used. To address RQ3, we performed LCA to uncover latent profiles. This method enables the identification of hidden patterns or structures within data by grouping individuals into homogeneous classes based on their response patterns to a set of variables. Furthermore, the model operates on probabilities, indicating the likelihood of specific categories of a manifest variable occurring (Langeheine & Rost, 1996). To determine the number of classes, the Akaike information criterion (AIC), the Bayesian information criterion (BIC), and the adjusted BIC were evaluated as information criteria (Table 2). The most widely reported is the BIC (Killian et al., 2019). The BIC rewards parsimony in models and can be used to compare competing LCA solutions. Lower BICs indicate better fit.

Table 2. Information-theoretical measures for different class solutions for Germany and Denmark.

Model	AIC	BIC	Adj. BIC	Entropy
1 class	9810.49	9913.13	9836.94	–
2 classes	9162.44	9371.99	9216.45	0.80
3 classes	8800.30	9161.77	8881.87	0.84
4 classes	8642.70	**9066.08**	8751.83	0.86
5 classes	8600.19	9130.49	8736.88	0.87
6 classes	8569.48	9206.70	8733.72	0.89
7 classes	8538.52	9282.66	**8730.33**	0.87
8 classes	**8531.10**	9382.15	8750.47	0.88

Note. AIC = Akaike information criterion, BIC = Bayesian information criterion, Adj. BIC = adjusted Bayesian information criterion, bold = smallest values.

Table 3. Information-theoretical measures for different class solutions for Germany.

Model	AIC	BIC	Adj. BIC	Entropy
1 class	4860.52	4945.60	4869.52	—
2 classes	4495.17	4668.89	4513.54	0.84
3 classes	4325.19	4587.53	4352.93	0.85
4 classes	4229.85	**4580.82**	4266.97	0.94
5 classes	4174.47	4614.07	4221.96	0.93
6 classes	**4137.53**	4665.76	**4193.39**	0.90

Note. AIC = Akaike information criterion, BIC = Bayesian information criterion, Adj. BIC = adjusted Bayesian information criterion, bold = smallest values.

Table 4. Information-theoretical measures for different class solutions for Denmark.

Model	AIC	BIC	Adj. BIC	Entropy
1 class	4786.90	4873.79	4797.69	—
2 classes	4314.89	4492.29	4336.92	0.87
3 classes	4191.26	**4459.17**	4224.53	0.86
4 classes	4127.29	4485.71	**4171.80**	0.89
5 classes	**4125.53**	4574.46	4181.28	0.89
6 classes	4128.13	4667.57	4195.12	0.85

Note. AIC = Akaike information criterion, BIC = Bayesian information criterion, Adj. BIC = adjusted Bayesian information criterion, bold = smallest values.

Table 2 shows that a four-class model can be assumed for the overall sample. In the country comparison, a four-class model can also be assumed for Germany (Table 3) and a three-class model for Denmark (Table 4).

The analysis of the LCA results and the model were performed using MPlus 8.3 (Los Angeles) software (Muthén & Muthén, 2019) to avoid bias due to missing estimates of the true value. Although the selection of the models was primarily based on statistical fit indices, the resulting profiles also exhibit interpretable response patterns. Therefore, the chosen solution is supported by statistical evidence and theoretical plausibility.

Results

RQ1: Teachers' perceptions of utilizing AI

The descriptive statistics describing teachers' perceptions of utilizing AI for teaching and learning in schools are shown in Table 5.

Differences between the two countries are evident regarding the perceived potential of AI-supported tools. Danish teachers ($M = 2.30$; $SD = 0.71$) stated that AI-supported tools can hinder students' comprehensive understanding of concepts, unlike German teachers ($M = 2.44$; $SD = 0.81$) ($t(508.19) = -2.13$, $p = .03$, $d = -19.$). German teachers ($M = 2.31$; $SD = 0.76$) considered AI-supported tools to be more effective in increasing students' interest in learning ($t(501.3) = 2.76$, $p = .006$, $d = .24$) compared to Danish teachers ($M = 2.48$; $SD = 0.65$). Among the German

Table 5. Teachers' perceptions of utilizing AI for teaching and learning in schools.

	N	*M*	*SD*
Using AI-based tools at school …			
… makes it difficult for students to develop a deep understanding of concepts.	532	2.37	0.76
… helps students develop a greater interest in learning.	532	2.40	0.71
… helps students to work at a level appropriate to their learning needs.	532	2.43	0.75
… helps students develop problem-solving skills.	532	2.66	0.80
… distracts students from learning.	532	2.30	0.79
… results in shorter attention spans among students.	532	2.46	0.81
… confuses students with false or misleading information.	532	2.24	0.79
… helps students develop skills in planning and self-regulation of their work.	532	2.31	0.77

Note. The scale ranged from 1 = strongly agree to 4 = strongly disagree.

cohort ($M = 2.33$; $SD = 0.76$), the usefulness of AI tools for individualized learning was recognized more strongly ($t(530) = 6.30$, $p < .001$, $d = .55$) compared to the Danish cohort ($M = 2.62$; $SD = 0.67$). Regarding the promotion of problem-solving skills through AI, German teachers ($M = 2.57$; $SD = 0.83$) tended to be more optimistic ($t(514.45) = 2.85$, $p = .023$, $d = .20$) than their Danish counterparts ($M = 2.73$; $SD = 0.75$). Concerns about AI tools leading to shorter attention spans were significantly more pronounced ($t(530) = 8.20$, $p < .001$, $d = .71$) among German teachers ($M = 2.17$; $SD = 0.83$) than Danish teachers ($M = 2.72$; $SD = 0.69$). Conversely, Danish teachers ($M = 2.14$; $SD = 0.74$) assessed AI's support for information processing significantly more positively ($t(524.62) = -5.26$, $p < .001$, $d = -0.46$) than German teachers ($M = 2.48$; $SD = 0.76$). There were no statistically significant differences in the perception that AI tools distract students from learning (Germany: $M = 2.3$; $SD = 0.82$; Denmark: $M = 2.29$; $SD = 0.76$) or that AI tools may provide misleading information (Germany: $M = 2.29$; $SD = .80$; Denmark: $M = 2.2$; $SD = 0.79$).

RQ2: Teachers' AI self-efficacy

For the AIK scale, a significant difference was found between German ($M = 3.39$, $SD = 0.88$) and Danish teachers ($M = 3.15$, $SD = 0.85$), $t(517) = -3.10$, $p = .002$. The effect size was small to moderate ($d = -0.27$). Similarly, in the AIP scale, German teachers ($M = 2.95$, $SD = 1.06$) reported higher self-efficacy than Danish teachers ($M = 2.62$, $SD = 1.02$), $t(517) = -3.59$, $p < .001$. The effect size was moderate ($d = -0.32$). For the AIA scale, German teachers ($M = 2.75$, $SD = 1.10$) reported significantly higher self-efficacy than Danish teachers ($M = 2.28$, $SD = 0.99$), $t(503.99) = -5.08$, $p < .001$. The effect size was moderate ($d = -0.45$). A similar pattern was observed for the AIE scale, where German teachers ($M = 3.28$, $SD = 0.97$) reported higher self-efficacy than Danish teachers ($M = 2.92$, $SD = 0.89$), $t(517) = -4.36$, $p < .001$. The effect size was moderate ($d = -0.38$). For the PEN scale, German teachers ($M = 3.08$, $SD = 1.05$) reported significantly higher self-efficacy than Danish teachers ($M = 2.47$, $SD = 0.99$), $t(517) = -6.81$, $p < .001$. The effect size was large ($d = -0.60$). For the HCE scale, no statistically significant difference was found between German ($M = 3.42$, $SD = 0.88$) and Danish teachers ($M = 3.29$, $SD = 0.87$). Overall, the results indicate that German teachers consistently reported higher self-efficacy in using AI-supported tools for teaching and learning compared to their Danish counterparts. The most pronounced differences were observed in the AIA and PEN scales, where large effect sizes suggest substantial differences. In contrast, no significant difference was found in the HCE scale. The descriptive statistics for all participants are presented in Table 6. There are 13 cases of missing data for these items.

RQ3: Distinct teacher profiles

RQ3a: All participating teachers

Table 7 presents the descriptive statistics for all participating teachers regarding the perceived benefits and challenges of AI-based tools for teaching.

Table 6. Descriptive statistics on teachers' AI competence and self-efficacy for teaching and learning in school.

	N	*M*	*SD*
AI Knowledge (AIK), α = .79	3.27	0.87	.79
I can distinguish whether a tool is AI-based or not.	519	3.06	1.07
I can create content with AI.	519	3.49	1.26
I can explain what AI is.	519	3.63	0.97
I know how to choose the right AI tools to effectively complete a task.	519	2.88	1.13
AI Pedagogy (AIP), α = .92	519	2.78	1.05
I can choose an AI tool to use in my classroom that enhances what I teach, how I teach, and what students learn.	519	2.83	1.11
I can choose an AI tool that enhances my teaching subject content for a lesson.	519	2.97	1.17
I can teach lessons that appropriately combine my teaching subject, AI tools, and teaching approaches.	519	2.74	1.18
I can help others coordinate the use of subject content, AI tools, and teaching approaches.	519	2.57	1.22
AI Assessment (AIA), α = .92	519	2.50	1.07
I can use AI tools to foster assessments for learning.	519	2.56	1.20
I can design an assessment approach to improve student learning in an AI-based environment (e.g. learning with ChatGPT).	519	2.55	1.23
I can assess student learning in an AI-based environment.	519	2.48	1.19
I can choose an AI tool to foster student self-assessment.	519	2.42	1.17
AI Ethics (AIE), α = .73	519	3.09	0.95
I can teach students ethics.	519	3.57	1.12
I can protect sensitive content from AI tools (e.g. exams, students' grades, and personal data).	519	2.68	1.27
I teach students how to behave safely and responsibly when learning with AI tools.	519	3.02	1.13
Human-centered education (HCE), α = .83	519	3.35	0.88
I can assess the benefits of an AI tool.	519	3.19	1.11
I can assess the risks of an AI tool.	519	3.26	1.11
I recognize humans are responsible for AI bias.	519	3.80	1.05
I can explain how AI impacts our society.	519	3.16	1.06
Professional engagement (PEN), α = .84	519	2.77	1.61
I can use different websites and search strategies to find and select a range of different AI tools.	519	2.96	1.18
I actively look for continuous professional development activities outside my educational organization.	519	2.72	1.40
I actively share my AI teaching experience with other colleagues within and outside my educational organization.	519	2.71	1.28
I love to help my colleagues design learning activities with AI.	519	2.69	1.30

Note. The scale ranged from 1 = strongly not agree to 5 = strongly agree.

Table 7. Descriptive statistics for all participating teachers regarding the perceived benefits and challenges of AI-based tools for teaching.

	Profile A			Profile B			Profile C			Profile D		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
IN[1]	17	1.65	0.86	28	3.61	0.50	209	1.91	0.46	278	2.69	0.54
LN[2]	17	1.12	0.33	28	3.89	0.31	209	1.90	0.47	278	2.76	0.49
PS[3]	17	1.29	0.47	28	3.82	0.48	209	2.17	0.60	278	2.99	0.60
PW[4]	17	1.53	0.51	28	2.46	1.14	209	2.30	0.67	278	2.34	0.79
DU[5]	17	3.70	0.59	28	3.50	0.75	209	2.04	0.52	278	2.92	0.58
DI[6]	17	2.94	0.97	28	3.68	0.55	209	2.21	0.62	278	2.96	0.68
AS[7]	17	2.82	0.95	28	2.25	1.27	209	2.59	0.73	278	2.52	0.79
MI[8]	17	3.00	1.12	28	3.71	0.53	209	2.78	0.61	278	3.01	0.70

Note. Items: Using AI-based tools in school….
[1]Helps students develop a greater interest in learning (interest, IN).
[2]Helps students to work at a level appropriate to their learning needs (learning needs, LN).
[3]Helps students develop problem-solving skills (problem-solving, PS).
[4]Helps students develop skills in planning and self-regulation of their work (planning work, PW).
[5]Makes it difficult for students to develop a deep understanding of concepts (deep understanding, DU) (r).
[6]Distracts students from learning (distraction, DI) (r).
[7]Results in shorter attention spans among students (attention span, AS) (r), and.
[8]Confuses students with false or misleading information (misinformation, MI) (r); scale ranged from 1 = strongly agree to 4 = strongly disagree; (r) = recode.

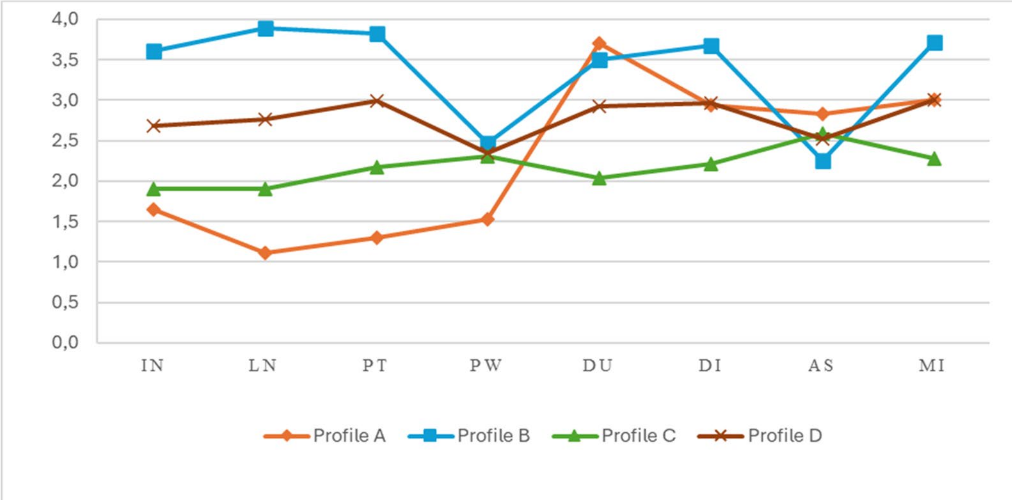

Figure 1. Results of the LCA for all participating teachers regarding the perceived benefits and challenges of AI-based tools for teaching.
Note. Means of the classes for the items. The items ranged from 1 = strongly agree to 4 = strongly disagree. IN = Interest; LN = Learning needs; PT = Problem-solving; PW = Planning work, DU = Deep understanding; DI = Distraction; AS = Attention span; MI = Misinformation.

The LCA results revealed four distinct classes with varying perspectives on the use of AI-based tools in education in Germany and Denmark (Figure 1). Each group demonstrates a distinct attitude toward the impact of AI on student learning, engagement, problem-solving, and potential drawbacks. We describe the classes/profiles as follows.

Profile A (3.2%), the critically reflective group, represents a small group with a generally positive attitude toward AI-based tools in education, recognizing their potential to enhance learning processes and personalization, while also expressing critical concerns about possible distractions, reduced attention, confusion, and negative effects on conceptual understanding. Profile B (5.26%), the critical group, comprises respondents with a critical stance toward AI in education, expressing skepticism about its benefits for engagement, personalized learning, and problem-solving while voicing concerns about its potential to distract and mislead, reflecting an overall cautious and wary attitude. Profile C (39.29%), the (rather) optimistic group, represents an optimistic group that supports the integration of AI-based tools in education, expressing strong confidence in their potential to enhance engagement, personalize learning, and promote problem-solving skills while showing minimal concern about possible distractions, misleading effects, or negative impacts on conceptual understanding. Profile D (52.26%), the ambiguous group, represents the largest group with a critically reflected and balanced view on AI in education, recognizing both its moderate benefits—particularly in engagement, personalized learning, and critical thinking—and potential drawbacks, such as distraction, misinformation, and challenges related to attention and self-management.

Overall, the results suggest diverse perspectives on AI-based tools for teaching and learning in schools. While some groups highlighted its positive impact on engagement and personalized learning, others emphasized risks such as distraction, misinformation, and reduced self-management. These insights can guide educators in developing strategies for AI integration that address both opportunities and challenges.

RQb3: Teachers in Germany

The LCA identified four groups of teachers in Germany (Figure 2). Profile A (5.50%) reflects a critically reflected group that strongly supports AI's potential for engagement, personalized learning, and self-management. This group also perceives significant cognitive challenges such as distraction and misinformation. Profile B (24.61%) represents an optimistic group that sees clear benefits of AI in fostering engagement and personalized learning, yet acknowledges certain challenges at home, particularly regarding distraction and a limited attention span. Profile C (15.63%) is a critical group that shows little confidence in AI's ability to support critical thinking or personalized learning while also reporting low self-management and high concern about distraction and misinformation. Profile D (54.3%) reflects an ambiguous group with a balanced and moderate view, neither strongly supporting nor opposing the impact of AI on learning and perceiving both benefits and challenges as relatively neutral (Table 8).

RQ3c: Teachers in Denmark

The LCA results for Denmark identified three distinct groups based on their responses (Figure 3). Profile A (35.14%) represents a rather optimistic group that sees moderate potential in AI for enhancing engagement, personalized learning, critical thinking, and self-management while acknowledging some learning challenges, resulting in an overall balanced perception. Profile B (52.54%) reflects an ambiguous group that is more reserved about AI's impact on engagement but recognizes its potential for self-management and deeper learning, alongside moderate concerns about attention and misinformation. Profile C (12.32%) is a critical group that perceives strong challenges related

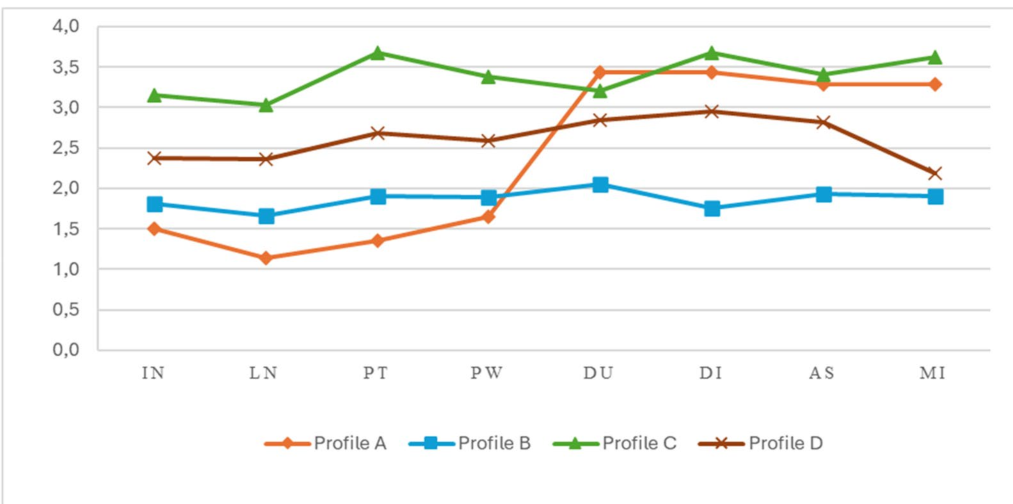

Figure 2. Results of the LCA for teachers in germany regarding the perceived benefits and challenges of AI-based tools for teaching.
Note. Means of the classes for the items. The items ranged from 1 = strongly agree to 4 = strongly disagree. IN = Interest; LN = Learning needs; PT = Problem-solving; PW = Planning work, DU = Deep understanding; DI = Distraction; AS = Attention span; MI = Misinformation.

Table 8. Descriptive statistics for teachers in germany regarding the perceived benefits and challenges of AI-based tools for teaching.

	Profile A			Profile B			Profile C			Profile D		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
IN	14	1.50	0.65	63	1.81	0.56	40	3.15	0.48	139	2.37	0.66
LN	14	1.14	0.36	63	1.67	0.57	40	3.03	0.73	139	2.36	0.55
PS	14	1.36	0.50	63	1.91	0.67	40	3.68	0.47	139	2.68	0.53
PW	14	1.64	0.50	63	1.89	0.57	40	3.38	0.54	139	2.58	0.59
DU	14	3.43	0.85	63	2.05	0.77	40	3.20	0.82	139	2.52	0.61
DI	14	3.43	0.51	63	1.76	0.50	40	3.40	0.59	139	2.84	0.62
AS	14	3.29	0.61	63	1.94	0.64	40	3.63	0.49	139	2.95	0.63
MI	14	3.29	0.91	63	1.90	0.53	40	3.40	0.54	139	2.81	0.62

Note. Scale ranged from 1 = strongly agree to 4 = strongly disagree.

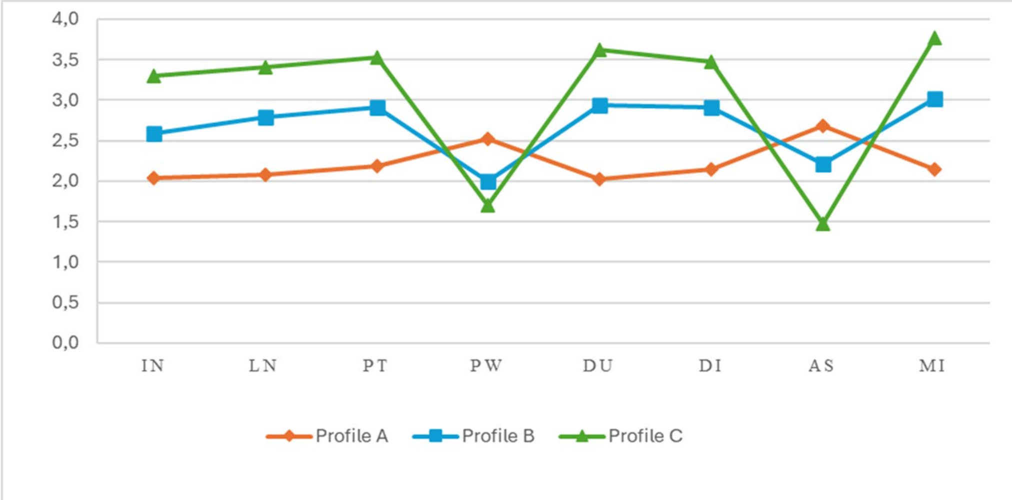

Figure 3. Results of the LCA for teachers in Denmark regarding the perceived benefits and challenges of AI-based tools for teaching.
Note. Means of the classes for the items. The items ranged from 1 = strongly agree to 4 = strongly disagree. IN = Interest; LN = Learning needs; PT = Problem-solving; PW = Planning work, DU = Deep understanding; DI = Distraction; AS = Attention span; MI = Misinformation.

Table 9. Descriptive statistics for teachers in denmark regarding the perceived benefits and challenges of AI-based tools for teaching.

	Profile A			Profile B			Profile C		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
IN	97	2.03	0.42	145	2.59	0.53	34	3.29	0.63
LN	97	2.08	0.53	145	2.79	0.48	34	3.41	0.56
PS	97	2.19	0.55	145	2.91	0.64	34	3.53	0.61
PW	97	2.52	0.61	145	1.99	0.72	34	1.71	0.72
DU	97	2.02	0.41	145	2.94	0.46	34	3.62	0.55
DI	97	2.14	0.52	145	2.91	0.63	34	3.47	0.75
AS	97	2.68	0.59	145	2.21	0.60	34	1.47	0.51
MI	97	2.14	0.43	145	3.02	0.66	34	3.76	0.50

Note. Scale ranged from 1 = strongly agree to 4 = strongly disagree.

Table 10. Summary of distinct teacher profiles regarding the perceived benefits and challenges of AI-based tools for teaching: participating teachers, teachers in germany, and teachers in denmark.

Participants	Critically reflective	(Rather) critical	(Rather) optimistic	Ambiguous
All participating teachers	3.2%	5.26%	39.29%	52.26%
Teachers in Germany	5.5%	15.63%	24.61%	54.3%
Teachers in Denmark	—	12.32%	35.14%	52.54%

to shallow learning, distraction, and misinformation. This group sees little educational benefit in AI but notably supports its role in fostering self-management (Table 9).

Table 10 offers a summary of the distinct profiles identified.

Discussion, implications, and future research

In this study, we examined the perspectives of school teachers in Germany and Denmark on AI for teaching and learning and their AI self-efficacy. Teachers in Germany reported a more positive attitude toward the integration of AI in schools compared to their Danish counterparts (RQ1). Furthermore, teachers in Germany self-reported higher AI self-efficacy for teaching and learning than their Danish counterparts (RQ2). Regarding the perceived benefits and challenges of AI-based tools for teaching (RQ3), we selected a model with four classes/profiles for all participating teachers and for teachers in Germany: critically reflective, (rather) critical, (rather) optimistic, and ambiguous. The fit indices (see Table 4) supports a three-class model for teachers in Denmark, which we selected: (rather) critical, (rather) optimistic, and ambiguous. This means the critically reflective profile did not apply to the Danish cohort. The four-class model is consistent with similar research among higher education teachers (Mah & Groß, 2024) regarding the perceived benefits and challenges of AI-based tools, despite the variation in group distribution. For instance, the previous study indicates that a greater proportion of university teachers were optimistic about the benefits of AI for teaching and learning (optimistic), and a greater proportion recognized both benefits and challenges (critically reflective) (Mah & Groß, 2024). The three-class model for Denmark, which is based on empirical data, may be consistent with the country's current policy of reverting to a less digital teaching and learning agenda (Ministry of Children and Education, 2019), as a shift toward promoting the integration of AI in education would suggest. However, given Denmark's extensive history and leading position with digital transformation in general and in education in particular, the participating teachers in this study appear to have expressed a rather ambiguous attitude toward the integration of AI in teaching and learning. This ambiguity seems to be characterized by a blend of optimism, criticality, and a reflective perspective. Overall, both countries exhibit a range of teacher profiles, from critical to optimistic. However, there are notable differences in the distribution of these profiles. German teachers are more frequently represented in the optimistic and critically reflective categories. In contrast, Danish teachers tend to cluster in the rather critical and ambiguous profiles.

Above all, these results demonstrate that even when a country is considered a front runner in the educational technology, the successful adoption of new technologies in schools requires significant further effort. Moreover, in both countries, a considerable number of teachers (Germany: 15.63%; Denmark: 12.32%) are critical of AI technologies and perceive little potential in AI adoption. This reluctance may lead to low adoption rates by teachers from this profile, which in turn could have detrimental effects on their students' acquisition of AI literacy, which is widely recognized as a crucial future competency (OECD, 2025; UNESCO, 2024a). Importantly, even teachers with a more positive outlook on AI may not integrate AI technologies meaningfully into their practice. Hence, for a meaningful AI integration continuous professional development courses are needed regardless of which profiles teachers belong to.

The differences between teachers' AI self-efficacy and perspectives on AI in Denmark and Germany also point to the need for professional development courses to be adjusted to the national educational systems and cultural attitudes in the respective countries. On the one hand, the difference in AI self-efficacy between Danish and German teachers may only be a perceptual difference caused by the students they interact with. As Danish teachers encounter students with higher digital literacy and as recent studies indicate also partially high degrees of AI usage (Dalsgaard & Prilop, 2025), they may perceive their own AI self-efficacy as lower in relation. Therefore, a more advanced digital literacy and AI literacy of the student body possibly results in a greater and faster need to build AI literacy for Danish teachers. In contrast, because digital technologies are less entrenched in the German school system, German teachers may not notice to what extent their students are already using AI tools and thus perceive less urgency to adapt. This may also help to explain why the stronger critical stance of Danish teachers toward AI as they are confronted with its use at a higher degree than their German counterparts. On the other hand, cultural factors may be equally relevant. In Germany, prevailing skepticism among German teachers regarding digital technologies persists (Eickelmann et al., 2024), with only approximately half of all teachers in Germany having employed genAI for educational purposes (Bitkom, 2024). Higher self-efficacy scores may be linked to recent initiatives of German federal states providing AI-based tools (e.g. school licenses) for teachers and students (Limpert, 2025). In Denmark, in contrast, a slight shift toward a more restrictive stance on digital technologies (Ministry of Children and Education, 2024) may affect Danish teachers' perspectives and involvement in genAI technologies. In the same vein, the absence of a critically reflective profile among Danish teachers may be linked to specific political initiatives, such as the Standing Scientific Commission on Educational Policy in Germany highlighting the potential of LLMs for the educational system (SWK, 2024), or several German states providing their teachers with dedicated AI-based tools. Such initiatives emphasize that LLMs can be advantageous for certain purposes yet problematic for others. This distinction aligns with the stance shown by teachers of the critically reflective profile.

Overall, the findings point to a need for targeted professional development courses, addressing the specific needs of teachers. Yet, a recent systematic review (Tan et al., 2025) indicates that teachers' development needs concerning AI integration remain underexplored. However, some studies suggest promising approaches for effective professional development courses. For example, Nazaretsky et al. (2022) found that fostering teachers' AI literacy can improve their trust and reduce their concerns regarding AI. This approach may be particularly effective for teachers in the critical profiles of the latent profile analyses. Furthermore, Ding et al. (2024) researched a professional development course that takes its participants' needs into consideration by relying on case-based discussion. Ding et al. (2024) found that collaboratively discussing the case problems enhanced their self-reported AI literacy. While these findings are encouraging, the present findings show that further research into effective professional development courses is required, as also noted by Tan et al. (2025).

Some limitations of this study should be considered. First, despite the selection of the class models (LCA) based on empirical data analyses, other models may (better) align with theoretical and practical assumptions. Nylund-Gibson and Choi (2018) recommended a sample size of 300 or more, based on numerous studies. However, smaller samples may be sufficient when dealing with simpler models—those with fewer indicators and classes—and with "well-separated" classes. When sample sizes are smaller, as in the case of the study of countries, potential issues with the analysis include poorly performing fit indices, convergence failures, and difficulties in identifying classes with low membership. Furthermore, although participants were recruited *via* an online survey panel, the extent to which this sample is representative of the entire teaching population in each country remains uncertain. This should be considered when interpreting the results. Second, a comparison and interpretation of the results require careful consideration of the cultural background, political strategy, and country-specific characteristics, as well as general attitudes toward digitalization. Third, we did not measure the effects that the countries' guidelines and political education programs, including the educational budget and its prioritization, have on teachers' perceptions of AI for teaching and learning. Consequently, it is not possible to draw conclusions on that matter, which was not an objective of this study. Third, the choice of instrument may have influenced the findings partially. The research team specifically selected the questionnaire after reviewing several other current instruments and discussed the applicability of items for the Danish and German context. Furthermore, translation of the questionnaire was conducted by a speaker of both languages. Yet, for future research a more systematic evaluation of cultural and linguistic equivalence is recommended. For a follow-up study, the research team is currently conducting a thorough content validation of the items for the German items. Moreover, self-reported AI self-efficacy is often not considered reliable, highlighting the need to develop objective instruments to measure AI self-efficacy and AI literacy (Chiu, Ahmad, et al., 2025; Chiu, Çoban, et al., 2025; Jin et al., 2025; Wang & Chuang, 2024). Nonetheless, the findings may function as a starting point for future research and international country comparisons (Bewersdorff et al., 2025; Delcker et al., 2024; Prilop et al., 2005). Thus, the results of the current study emphasize its rather exploratory nature and demonstrate the importance of continued research in this area.

Future research should include both international comparisons and assessments of teachers' and students' perspectives on the integration of AI into the educational sector, such as the large-scale studies PISA and ICILS (Fraillon, 2024; OECD, 2023). Furthermore, longitudinal studies, as well as qualitative and mixed-method studies, have the potential to offer profound insights that could assist stakeholders—including educational policymakers, researchers, and practitioners—in developing professional development activities. These insights could empower teachers and students in the age of AI for teaching and learning in school and beyond (OECD, 2025).

Conclusion

The study revealed significant differences between Danish and German teachers' AI self-efficacy and their perspectives on benefits and challenges of AI in teaching and learning. These findings highlight that the educational and cultural context needs to be taken into consideration for successful AI adoption. Despite countries like Denmark having been frontrunners regarding technology integration in the past, continuous professional development is required for a meaningful AI integration. Furthermore, the study showed that a considerable number of teachers in both countries are critical about AI. Their skepticism could lead to low adoption rates in the classroom. As this could be detrimental to students developing sufficient AI literacy skills, this challenge needs to be addressed. Future research should therefore investigate how context-sensitive professional development courses can be implemented to support the needs of specific teacher profiles. To support meaningful AI adoption in schools, continuous professional development must be adapted to teacher profiles and contextual factors. Future research should investigate how targeted, context-sensitive interventions can support teachers across profiles and countries. Additionally, international comparative studies can help identify strategies that can be generalized to effectively foster AI integration, ensuring that students develop the necessary AI literacy for future educational and professional contexts.

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