Mah and Groß
International Journal of Educational Technology in Higher Education (2024) 21:58
https://doi.org/10.1186/s41239-024-00490-1

International Journal of Educational Technology in Higher Education

RESEARCH ARTICLE Open Access

Artificial intelligence in higher education: exploring faculty use, self-efficacy, distinct profiles, and professional development needs

Dana-Kristin Mah[1*] and Nele Groß[1]

*Correspondence:
Dana-Kristin Mah
dana-kristin.mah@leuphana.de
[1]Institute of Educational Sciences, Leuphana University of Lüneburg, 21335 Lüneburg, Germany

Abstract
Faculty perspectives on the use of artificial intelligence (AI) in higher education are crucial for AI's meaningful integration into teaching and learning, yet research is scarce. This paper presents a study designed to gain insight into faculty members' ($N = 122$) AI self-efficacy and distinct latent profiles, perceived benefits, challenges, use, and professional development needs related to AI. The respondents saw greater equity in education as AI's greatest benefit, while students and faculty members' lack of AI literacy was among the greatest challenges, with the majority interested in professional development. Latent class analysis revealed four distinct faculty member profiles: optimistic, critical, critically reflected, and neutral. The optimistic profile moderates the relationship between self-efficacy and usage. The development of adequate support services is suggested for successful and sustainable digital transformation.

Keywords AI self-efficacy, AI literacy, Artificial intelligence in higher education, Faculty perspective, Digital transformation, Latent class analysis

Introduction

There are several benefits for faculty members who apply artificial intelligence (AI) to teaching practices in higher education. AI-based tools for teaching and learning, such as large language models (LLMs) and learning analytics, encompass improved planning and resource allocation, greater insight into student learning, and data-driven feedback on instructional design, which might lead to a more efficient and effective teaching process (Bond et al., 2023; Crompton & Burke, 2023; Zheng et al., 2024). However, the integration of educational and AI-based technologies into teaching and learning is not without its challenges, the main ones being curriculum development, infrastructure, and a lack of ethical consideration and teachers' technical knowledge (Bond et al., 2023). In recent years, AI's potential in education has been increasingly recognized, which can be seen from the increasing number of publications in the field of AI in education (AIEd), leading to AI's growing adoption in various educational practices (Chiu, 2023; Crompton & Burke, 2023; Grassini, 2023; Ouyang et al., 2022). This contrasts with the findings of

Zawacki-Richter et al. (2019), who, at a time when research on AI was predominantly conducted by the STEM disciplines, called for more educators to be engaged. The public release of the ChatGPT LLM by OpenAI in late 2022 particularly extended interest in AI to a broad civic audience and, to a large extent, higher education institutions. Given its accessibility and easy-to-use interface, ChatGPT has sparked diverse global reactions from the academic community, ranging from outright bans to cautious acceptance and adaptation (Kasneci et al., 2023; Mah, 2023). Adopting new and (apparently) disruptive technologies is key in an increasingly digitalized world (Redecker, 2017; Vuorikari et al., 2022). Higher education institutions play an important role and should actively shape the digital future of AI in education in a meaningful and human-centered way. In doing so, the perspectives of stakeholders (e.g., faculty, students, administration) are crucial, as are acceptance, transparent communication, and professional development, for becoming digitally and AI literate (Chiu et al., 2023; Ifenthaler & Yau, 2019; Redecker, 2017). Facing rapid and complex developments, such as AI, higher education institutions may not be prepared to deal with unsolved issues, such as ethics and privacy, assessment practices, and the competent use of AI for teaching and learning (Ifenthaler, 2017; Kohnke et al., 2023). Thus, to meaningfully integrate AI into higher education, it is essential to consider all stakeholders' perspectives. While there is increasing research available on students' perspectives and use of AI in learning (Delcker et al., 2024; Gašević, 2023; Hornberger et al., 2023; Johnston et al., 2024), research on faculty perspectives is scarce. Faculty members' views on the adoption and use of AI in teaching practices, as well as their interest in professional development regarding AI for teaching and learning, have been relatively underexplored (Liu et al., 2020). Faculty members, however, are not only educators but also role models for students in demonstrating the appropriate use of AI in educational contexts (Bećirović, 2023; Pratschke, 2024). Their preparedness, proficiency, and self-efficacy (Bandura, 1977) in AI are pivotal for ensuring that students acquire necessary twenty-first-century skills, including AI literacy (Long & Magerko, 2020; Ng et al., 2021; Pinski & Benlian, 2024). In this regard, lecturers—as an essential part of higher education institutions—may provide a platform for discussion about AI in education, covering aspects such as opportunities, challenges, ethical and privacy issues, implications for assessments, fears, and hopes.

This paper presents a study designed to gain insight into faculty members' perspectives on the use of AI in higher education. It focuses on understanding their AI self-efficacy as well as perceived benefits, challenges, interests, and needs in terms of professional development with regard to integrating AI into their teaching practices. In addition, we examine latent profiles based on faculty members' perceptions of the benefits and challenges of AI-based tools for teaching and learning. This research contributes to the evolving discourse on AI in education by broadening the focus from the student's perspective to that of the lecturer, thereby providing a more holistic understanding of the role of AI in higher education. Thus, this study aims to elucidate the current state of AI integration in teaching practices and the professional development needs of lecturers, setting the stage for a more informed and effective implementation of AI in higher education for teaching and learning.

Theoretical background

AI-based tools for teaching and learning in higher education

The research landscape concerning AI-based tools for teaching and learning in higher education has seen sustained exploration over the years (Chan & Hu, 2023; Crompton & Burke, 2023; Joksimovic et al., 2023; Law, 2024; Zawacki-Richter et al., 2024). Notably, within the domain of AI research in higher education, several critical areas have emerged as focal points of investigation. These include assessment practices with regard to misuse/cheating, and the evaluation of AI tools and their impact on pedagogy (Hodges & Kirschner, 2024; Mao et al., 2023; Xia et al., 2024) has highlighted the significance of these endeavors. Furthermore, the field of learning analytics, which has been the subject of research for over a decade, still faces limited practical adoption in higher education institutions (Márquez et al., 2023; Tsai et al., 2020). This limitation may be attributed to the unpreparedness of higher education institutions and the paucity of professionals well versed in this domain (Ifenthaler, 2017; Kohnke et al., 2023). The growing number of systematic reviews on AI in higher education often group AI-based tools into similar categories (Bond et al., 2024; Crompton & Burke, 2023; Zawacki-Richter et al., 2019). For instance, Crompton and Burke (2023) categorized the utilization of AI in higher education into five primary domains: assessment/evaluation, prediction, AI assistants, intelligent tutoring systems, and managing student learning. These categories provide a comprehensive framework for understanding the diverse applications of AI in higher education. The application of generative AI in education has recently been the subject of intensive research. The rapidly increasing body of scientific studies provides valuable insight into how learners and teachers in higher education and K-12 are already utilising generative AI for learning and teaching purposes (Chan & Colloton, 2024; Stanford University, 2024; Yusuf et al., 2024). Some studies examine the potential benefits and challenges of generative AI in education in general (Bond et al., 2023; Pratschke, 2024), whereas others focus on specific aspects, such as instructional design considerations (Choi et al., 2024; Mollick & Mollick, 2024), and AI-based applications such as LLMs and image AI generators (Chiu, 2023; Crompton & Burke, 2024; Law, 2024). The use of AI-based tools in teaching and learning gives rise to a number of critical considerations, including the ethical implications of AI, the necessity for AI literacy among both learners and educators, and the development of appropriate AI literacy frameworks for educational settings. These issues are being addressed in a growing body of research and in the development of new AI literacy frameworks for educational settings (Celik, 2023b; Mishra et al., 2023; Nguyen et al., 2023; UNESCO, 2024a, 2024b).

Faculty perspectives on and role in driving AI literacy and digital transformation in higher education

In recent years, higher education institutions worldwide have been navigating the challenging terrain of digital transformation, compelled by factors such as the integration of digital tools, instructional design modifications, and digital assessments and the exigencies posed by the COVID-19 pandemic (Singh et al., 2021; Xie et al., 2021). Within this context, faculty members stand at the forefront, grappling with the need for support to adapt effectively to the digital transformation landscape. While many higher education institutions have returned primarily to traditional teaching and learning practices, especially face-to-face formats, some have integrated blended learning and other

online elements to achieve sustainable change (Broadbent et al., 2023; Cobo-Rendón et al., 2022). Digital transformation within the higher education sector is a complex process that requires sophisticated change management strategies and involves a variety of stakeholders. Faculty members have a crucial role to play as key stakeholders in this transformation (McCarthy et al., 2023; Mohamed Hashim et al., 2022). The challenges and concerns they face include issues of acceptance, trust, and apprehension and ethical considerations related to the incorporation of AI into pedagogy, as well as concerns about potential cheating, necessitating an in-depth exploration of lecturers' perspectives. One prominent aspect affecting the acceptance of AI and digital transformation among lecturers is lecturers' perceived self-efficacy (Ajzen, 2002; Bandura, 1977) and literacy in utilizing these technologies (Ng et al., 2023; Wang et al., 2023). Lecturers who feel well informed and competent about technology-/AI-related topics tend to exhibit greater openness to embracing technology-/AI-driven educational tools and methodologies (Venkatesh & Davis, 2000). Consequently, investing in the professional development of lecturers has emerged as a fundamental requirement (Eickelmann et al., 2021; Sanusi et al., 2024). To empower faculty members with the necessary knowledge and skills, comprehensive professional development programs are essential. These programs should encompass a general introduction to AI, AI's applications in education, its legal aspects, and its specific role in teaching and learning. It is vital to emphasize that AI should be viewed as a tool to support lecturers rather than as a means to replace them. Professional development for lecturers can be facilitated through digital learning platforms, such as Coursera and edX, which offer online courses on AI in education. However, a more tailored approach that caters specifically to the unique needs and challenges faced by faculty in higher education institutions is often needed (Laupichler et al., 2022). Thus, while there are some professional development courses available, there is a need to explore more deeply the perspectives of faculty members on their actual needs for the competent integration of AI into teaching and learning practices to provide adequate and tailored support.

Research questions

Against this background, this paper addresses the following research questions:

RQ1: How do faculty members perceive the benefits and challenges of AI for teaching and learning in higher education? What are their greatest benefits and challenges?
RQ2: What distinct faculty member profiles can be identified through a latent class analysis regarding the perceived benefits and challenges of AI-based tools?
RQ3: To what extent have faculty members employed AI applications (either privately or for teaching purposes), and for what purposes have they been used in the context of teaching?
RQ4: To what extent are there moderating effects of the different profiles (RQ2) on the relationship between AI self-efficacy and usage?
RQ 5: Are faculty members interested in pursuing professional development in the area of AI for teaching and learning in higher education? If so, which topics, which formats, and how much time do they intend to spend?

Methods

Sample and data collection

A total of 122 academic staff members from various higher education institutions (e.g., universities and universities of applied sciences) across Germany participated in this study. Of the participants, 53 identified as male, 34 identified as female, and two identified as other, while 33 preferred not to answer. The participants' average age was 43 years (SD=10.31, min=20 max=69). Faculty members were invited to participate in the study through newsletter announcements from digital teaching and learning communities as well as through three higher education events on AI in education (i.e., presentations and teaching days). Data were collected from late 2023 to early 2024 via an online questionnaire.

Instrument and data analysis

The questionnaire that had been developed consisted of closed questions, open-ended questions, and sociodemographic information. Most of the items were adapted from the literature, while some were newly developed.

Benefits and challenges of AI in education for teaching and learning

Following the results of the systematic review of AI in higher education conducted by Bond et al. (2023), the key benefits (e.g., personalized learning) and challenges (e.g., lack of ethical consideration) were adapted to gain insight into the perspectives of lecturers. The items were answered using a five-point scale (1=strongly disagree, 5=strongly agree; example item: "The potential of AI-based applications for teaching and learning is … personalized learning").

Use of AI-based tools

Several items were used to measure the use of AI-based tools by lecturers, such as extent (example item: "How often have you used AI-based applications in/for your teaching in the last 6 months?"; 1=never, 5=very often), usage scenario (example item: "I use AI-based applications for … the design/preparation of my lessons"; 1=never, 5=very often), and categories of AI use adapted from Zawacki-Richter et al. (2019). The Cronbach's alpha for the scale is 0.58.

AI self-efficacy: utilizing AI tools for personal use and for teaching and learning

To determine the utilization of AI tools for personal use and for teaching and learning, we added some self-developed aspects and some self-efficacy aspects adapted from the technological, pedagogical, and content knowledge (TPACK) framework (i.e., technology knowledge, TK, and technological and pedagogical knowledge, TPK) (Celik, 2023b; Schmidt et al., 2009) and from Ng et al. (2023a) (example item: "I can teach lessons that appropriately combine my course content, AI-based tools, and teaching strategies"; 1=strongly disagree, 5=strongly agree). The scale consisted of six items and had a Cronbach's alpha of 0.86.

Professional development in AI-based tools for teaching and learning

Several items were used to measure different aspects of professional development in AI for teaching and learning, such as interest in professional development in AI (AI as a

tool, AI as a learning object, AI for research; nominal scale), and, each on a five-point scale (1 = strongly disagree, 5 = strongly agree), interest in different types of exchange formats (e.g., general information sessions, interactive workshops), types of AI-based applications (e.g., large language models, image generator) and formats (e.g., face-to-face, blended, online), and time spend.

Data analysis

The descriptive statistics and preparation of data for multivariate analyses were carried out using IBM SPSS 28 software (IBM Corp., 2021). To analyze group differences (RQ1, RQ3), one-way analysis of variance (ANOVA) was conducted and a Gabriel post hoc test was carried out according to Field (2013). To identify latent profiles (RQ2), we conducted a latent class analysis (LCA). An LCA is used to identify patterns or structures in data that are not obvious by classifying individuals into homogeneous groups based on their patterns of response to a set of variables. In addition, the model is based on probabilities that indicate how likely it is that a particular category of a manifest variable will occur (Langeheine & Rost, 1996). To determine the number of classes, the Akaike information criterion, Bayesian information criterion (BIC), and adjusted BIC were evaluated as information criteria (Table 1). The lower these indicators were, the better the model fit. Analyses of the latent classes and the model were performed using MPlus 8.3 software (Muthén & Muthén, 2019) to avoid bias due to missing estimates of the true value. The Voung–Lo–Mendell–Rubin test (Lo et al., 2001) showed that the four-class model fit was significantly better than the three-class model ($p = 0.76$) and the five-class model ($p = 0.76$). The entropy value for the four-class model was 0.95. This high entropy value indicated good classification quality, suggesting that the model would effectively differentiate between the latent classes. To analyze RQ4, we conducted regression analyses.

Results

RQ 1: Faculty members' perceived benefits and challenges regarding AI in education for teaching and learning

Table 2 presents faculty members' perceived benefits and challenges of AI for teaching and learning in higher education.

Perspectives on the AI tool's potential to positively impact learning outcomes varied significantly by age ($F[4, 86] = 4.687$, $p = 0.002$). Levene's test confirmed the homogeneity of variances ($p = 0.254$). Post-hoc analysis using the Gabriel test revealed significant differences between individuals under 30 years ($M = 2.5$, $SD = 0.56$) and those aged 30–39 years ($p = 0.02$, 1.11, 95% CI[-2.13, −0.09]; $M = 3.61$, $SD = 1.03$) as well as between those under 30 years and individuals aged 40–49 years ($p = 0.03$, 1.00, 95% CI[-1.95, −0.05]; $M = 3.5$, SD = 0.90). People aged 50–59 years ($p = 0.25$, 1.55, 95% CI[-2.6, −0.50]; $M = 4.05$,

Table 1 Information-theoretical measures for different class solutions

Model	AIC	BIC	Adj. BIC
1 Class	3533.17	3653.56	3514.49
2 Class	3358.52	**3602.04**	3320.74
3 Class	3287.11	3653.76	3230.23
4 Class	**3273.54**	3763.32	**3197.56**
5 Class	3284.16	3897.06	3189.08

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

Table 2 Descriptive statistics of the benefits and challenges of AI-Based tools for teaching and learning

	N	M	SD
Potentials			
Personalized learning	112	2.66	0.83
Greater insight into student understanding	110	3.44	1.14
Positive influence on learning outcomes	110	3.46	1.05
Reduced planning and administration time for teachers	113	3.2	1.28
Greater equity in education	108	3.63	1.4
Precise assessment and feedback	111	3.34	1.28
Challenges			
Lack of ethical consideration	114	2.88	0.94
Curriculum development	111	2.96	1.00
Infrastructure	111	2.86	1.14
Lack of AI literacy among faculty	113	2.77	0.89
Lack of learners' AI literacy	112	2.99	1.04

Note The scale ranged from 1 = strongly disagree to 5 = strongly agree

Fig. 1 Means of the Four Classes for the Benefits and Challenges of AI-Based Tools. *Note* Means of the classes for the items. The items ranged from 1 = strongly disagree to 5 = strongly agree. Benefits: PL = personalized learning, SU = student understanding, PI = positive influence learning outcomes, RP = reduced planning, GE = greater equity, A&F = assessment and feedback; challenges: EC = ethical consideration, CD = curriculum development, Is = infrastructure; AIL_f = AI literacy faculty, AIL_s = AI literacy students. Profiles: A = optimistic, B = critical, C = critically reflected, D = neutral

SD = 0.89) and over 60 years (p = 0.02, 1.50, 95% CI[-2.88, −0.12]; *M* = 4.0, *SD* = 0.63) also differed significantly from those under 30 years. People over 30 years rated the positive impact of AI-based applications on learning outcomes significantly higher than faculty members under 30 years old. Regarding challenges, no significant differences were observed across age groups.

RQ 2: distinct faculty member profiles regarding the perceived benefits and challenges of AI-based tools

The latent class analysis (LCA) identified four distinct classes based on faculty perceptions of the benefits and challenges of AI tools for teaching and learning (Fig. 1). We described the classes/profiles as follows: *Optimistic* (Profile A; 33.5%): Faculty in this class somewhat agree with the benefits of AI-based tools and agree less with the challenges; *Critical* (Profile B; 27.3%): These faculty members are critical of AI-based tools

and somewhat disagree with the benefits and tend to agree with the challenges; and *Critically reflected* (Profile C; 33.9%): Faculty members in this class agree with the perceived benefits and are also critical of the challenges of AI-based tools. *Neutral* (Profile D; 5.3%): Faculty members in this class rate both the benefits and challenges as low.

Table 3 presents the descriptive statistics of the four identified profiles based on faculty perceptions of the benefits and challenges of AI tools for teaching and learning.

RQ 3: Faculty use of AI-based tools

In the previous 6 months, the majority of faculty members had used AI-based tools for personal, teaching, or outside work (Table 4); none had used them in all three areas surveyed, but 84% had used them in two areas.

Of the respondents, one-third frequently integrated AI-based tools into their teaching, while one-quarter had never done so. Faculty members reported using AI-based tools most often for the conception and preparation of teaching ($M=2.95$, $SD=1.15$). With regard to faculty use of AI applications, the data showed no significant differences among the various age groups.

RQ 4: moderating effect of latent profiles on the relationship between AI self-efficacy and AI usage

The regression model showed a significant relationship between AI self-efficacy and usage ($\beta=49$, $p\leq0.001$). We examined the moderating effects of three profiles (A, B, and C; profile D was too small for analysis) on the relationship between AI self-efficacy (independent variable) and usage (dependent variable). The results are summarized as follows. The interaction term between AI self-efficacy and profile A was significant ($b=0.66$, $SE=0.27$, $p<0.02$), indicating that profile A (optimistic) significantly moderates the relationship between self-efficacy and usage. The interaction terms between AI self-efficacy and profile B (b = -0.50, $SE=0.48$, $p=0.30$) and profile C (b = -0.44, $SE=0.36$, $p=0.23$) were not significant. The effect of self-efficacy on usage therefore remained the same regardless of affiliation with profile B or profile C.

RQ 5: Faculty interest in professional development

Faculty members were found to be interested in training in AI-related topics. The majority of respondents (78.5%) indicated that they would be interested in training in formats on teaching and learning with AI-based tools, two-thirds (66.4%) were interested in training in AI-based tools, half (48.6%) were interested in training in AI in research, and 8.4% did not plan to invest any time in training in AI-based tools. Most respondents planned to invest between 5 and 20 h in AI-related professional development activities. Nearly half (48.8%) of the respondents indicated that their motivation for attending training and discussion formats was to pursue their curiosity about AI-based applications for teaching and learning, and nearly half (46.4%) strongly/mostly agreed that they would like to learn more about AI-based applications. Table 5 presents the descriptive statistics for RQ5.

Table 3 Descriptive statistics of the Four profiles based on Faculty Members' perceptions of the benefits and challenges of AI tools for teaching and learning

	Profile A			**Profile B**			**Profile C**			**Profile D**		
	N	***M***	***SD***	***N***	***M***	***SD***	***N***	***M***	***SD***	***N***	***M***	***SD***
PL	37	1.65	0.86	31	1.35	0.61	38	2.18	0.46	6	0.00	0.00
SU	38	2.76	1.03	28	1.75	0.80	38	3.00	0.74	6	0.00	0.00
PI	36	2.94	0.72	31	1.65	0.76	37	2.97	0.60	6	0.67	1.63
RP	37	2.43	1.14	31	2.19	1.11	39	2.23	1.35	6	0.67	1.63
GE	37	2.76	1.54	29	2.21	0.82	36	3.28	1.11	6	0.00	0.00
A&F	37	2.57	1.35	31	1.61	0.88	37	3.03	0.90	6	0.50	1.23
EC	38	1.39	0.76	31	2.26	0.93	39	2.21	0.66	6	0.83	1.60
CD	36	1.53	0.70	30	2.17	1.09	39	2.38	0.78	6	0.83	1.60
Is	37	1.78	1.16	31	2.03	1.11	37	2.00	1.05	6	0.67	1.21
AIL_f	38	1.63	0.75	30	1.77	0.97	39	2.05	0.69	6	0.83	1.60
AIL_s	38	1.61	0.76	30	2.20	1.03	38	2.42	0.89	6	0.67	1.63

Note Means of the classes for the items. Scale from 1 = strongly disagree to 5 = strongly agree. Benefits: PL = personalized learning, SU = student understanding, PI = positive influence learning outcomes, RP = reduced planning, GE = greater equity, A&F = assessment and feedback; challenges: EC = ethical consideration, CD = curriculum development, Is = infrastructure, AIL_f = AI literacy faculty, AIL_s = AI literacy students

Table 4 Descriptive statistics of actual use of AI-Based tools

	N	M	SD
Use in the last 6 month			
Private	118	3.75	1.25
In/for teaching	88	3.19	1.13
For work (outside of teaching)	24	3.25	1.4
Use …			
for the conception/preparation of teaching	85	2.95	1.15
for didactic teaching (teaching and learning with AI)	86	2.64	1.28
for teaching and learning about AI	86	2.77	1.35
for profiling (e.g., predicting study success at the course level)	86	1.22	0.60
as intelligent tutoring systems	86	1.63	0.93
for exams/evaluation	85	1.61	0.93
as adaptive systems/for personalization	86	1.64	1.01

Note The scale ranged from 1 = never to 5 = very often

Discussion

Summary of the results

Our study reveals faculty perspectives on a number of aspects of AI for teaching and learning in higher education. Respondents rated the aspect of greater equity in education as the greatest benefit. Indeed, Bond et al. (2023) showed AI for educational equity to be among the top seven benefits identified in their meta-systematic review. In addition, AI can empower learners with disabilities and lead to more inclusive learning—for example, when large language models coupled with speech-to-text and text-to-speech technologies provide significant support for visually impaired learners by facilitating tasks such as adaptive writing, translation, and content highlighting (Kasneci et al., 2023). An experimental philosophical study (McGrath et al., 2023) of university teachers' perceptions of responsibility and AI in higher education found a broad consensus among participants that universities should provide AI educational tools, especially to support first-generation students and those with learning disabilities, reflecting a commitment to equity and fairness, as argued by Prinsloo and Slade (2017). In addition, issues such as data bias, the digital divide, access to (paid-for) AI tools and licenses, and AI literacy, among other ethical challenges, should be discussed in the context of greater equity in education (Celik, 2023a). The greatest challenge of AI for teaching and

Table 5 Descriptive statistics of the Professional Development of AI-Based tools

	N	M	SD
Support formats on AI			
General information sessions	67	3.37	1.38
Information sessions on individual AI-based tools	82	3.48	0.98
Interactive workshops on AI-based tools	83	3.37	0.88
Interactive workshops for general exchange	79	3.51	0.95
Teaching/learning formats			
Face-to-face events	83	2.98	1.38
Online sessions	86	4.26	1.03
Blended learning (combination of face-to-face and online)	84	3.31	1.33
Digital self-learning courses	85	3.52	1.39
Support offer for type of AI-based applications			
Speech models	85	3.95	1.21
Image generators	84	3.50	1.35
Literature search/preparation tools	84	4.19	1.06

Note The scale ranged from 1 = strongly disagree to 5 = strongly agree

learning, according to the participants, was the lack of AI literacy among learners. This finding is striking because (a) AI literacy is a relatively new construct being discussed in higher education for teaching and learning and (b) the few studies available on this topic tended to show low levels of (self-reported) AI literacy among faculty (Almatrafi et al., 2024; Chiu et al., 2024; Long & Magerko, 2020; Pinski & Benlian, 2024).

In addition, we were able to identify four distinct profiles (LCA) of faculty members' perspectives on AI for teaching and learning based on their perceived benefits and challenges, which we labeled optimistic, critical, critically reflective, and neutral. Of these, the optimistic and critically reflective profiles each encompassed one-third of the participating faculty members, representing the majority. The critical profile was slightly less represented, and the neutral profile consisted of only 5% of faculty members. Thus, our results indicate a rather optimistic and critically reflective perspective on AI for teaching and learning, in contrast with findings showing that over one-third of faculty members were neutral (Preiß et al., 2023). It may be hypothesized that more faculty members have tried AI-based tools between these studies since there has been a growing discussion about AI in education, and hence numerous guidelines have been formulated by individual higher education institutions, the European Commission, and educational organizations that aim to offer introductory insights into and practical examples of the integration of AI into education (Gimpel et al., 2023; Moorhouse et al., 2023; Southworth et al., 2023; UNESCO, 2023). This may contribute to a critical reflective attitude toward AI for teaching and learning.

In addition, in terms of AI self-efficacy, we found that the optimistic profile moderated the relationship between self-efficacy and the usage of AI for teaching and learning. This is in line with research that shows a positive impact of technological self-efficacy on technology acceptance and utilization (Venkatesh & Davis, 2000).

Further, regarding the use of AI tools for teaching and learning, our study showed that the highest rating was for the conception/preparation of teaching. This is in line with studies that have highlighted the potential of generative AI to inspire ideas such as the design of lessons and instructional design (Chiu et al., 2023; Choi et al., 2024; UNESCO, 2023). Profiling, on the other hand, was ranked lowest. This finding is consistent with research showing that higher education remains slow to adopt learning analytics (Márquez et al., 2023; Tsai et al., 2020). With regard to age, participants over 30 rated the positive impact of AI-based tools on learning outcomes significantly higher than those under 30 years. With regard to the relationship between age and general attitudes toward AI, the research findings are contradictory. Schepman and Rodway (2023) showed that younger people were more likely to show positive general attitudes toward AI than older people, while Kaya et al. (2024) showed that age did not predict attitudes toward AI.

Finally, this study showed that the majority of faculty members were interested in professional development in AI-related topics. However, research on schoolteachers has shown that few teachers have participated in technology-related professional development—that is, courses that help teachers develop high-quality digital teaching (Eickelmann et al., 2021). Studies have suggested that the perceived usefulness of technology in the classroom is a strong predictor of intentions to participate in technology-related professional development (Fütterer et al., 2023a; Luckin et al., 2022). Luckin et al. (2022) presented a framework for developing AI readiness training for educators, including

seven steps (excite, tailor and hone, identify, collect, apply, learn, and iterate). They emphasized the contextualization of AI and AI readiness in terms of the diversity of occupations, workplaces, and sectors as well as the empowerment of people in active engagement to better use AI to meet their needs. In terms of format for professional development, most participants preferred self-paced online courses and online sessions to face-to-face and blended learning formats. Online courses, especially in asynchronous and self-paced formats, allow participants to access learning content and materials on their own and to learn independently of time and place (Schmid et al., 2023). This is in line with the increase in online professional development activities for (school) teachers in recent years, and studies have indicated teachers' satisfaction with online professional development (Bichler et al., 2021; Meyer et al., 2023; Mulaimović et al., 2024). There are many digital learning platforms that offer online courses and other digital learning formats on AI, such as Coursera, EdX, FutureLearn, Udemy, and the AI campus (Mah, 2023), but faculty professional development is often organized by university support services themselves and in face-to-face formats.

Limitations

This study has some limitations that should be considered. We used data from only 122 faculty members at higher education institutions. Thus, the sample size was rather small, which underscores the exploratory nature of the study and suggests caution in generalizing the findings beyond the current sample. In addition, newsletters and events on digital teaching and learning and AI in education were used to promote the survey. Therefore, the respondents were already interested in the topic and may have been early adopters. Furthermore, our analysis was based on self-reporting, so misreporting, overestimation, and underestimation (Kruger & Dunning, 1999) cannot be completely ruled out. Consequently, the results should be viewed as preliminary, necessitating further research with a more extensive sample to validate these initial findings.

Conclusion, implications, and future research

The results of this research provide valuable insights into faculty perspectives on the perceived benefits and challenges of AI and AI utilization, self-efficacy, and professional development in higher education. They provide initial insights that can serve as a critical starting point for understanding regional nuances in the application of AI in education and for appropriate professional development services.

By offering a deeper understanding of faculty perspectives on AI, this research serves as a vital conversation starter, laying the groundwork for a broader, more inclusive dialog among lecturers and other key stakeholders in the educational sector. Higher education institutions stand to benefit greatly from these insights. The findings offer a unique opportunity to refine and enhance support services, including teaching and professional development services. A crucial aspect of this enhancement is the focus on AI-specific topics and the exploration of various delivery formats, including online platforms. These tailored services can help address the specific needs and concerns of lecturers regarding AI integration into their teaching, ensuring that the implementation is both effective and meaningful.

Furthermore, the results of this study can promote constructive dialog within academic institutions. Such dialog would not just be limited to the pedagogical aspects but

also extend to the ethical and practical implications of AI in education. Studies examining the perspectives of experts in the field of AI in education may assist in the prioritization of key areas for discussion and action. For example, an international Delphi study indicates that the challenges of privacy and ethical usage of AI, trustworthy algorithms, and equity and fairness in the field of AI in education are of particular importance (Ifenthaler et al., 2024).Therefore, appropriate models for AI literacy, both interdisciplinary and domain-specific, need to be discussed and developed, as well as for AI self-efficacy (Lintner, 2024; Wang & Chuang, 2024). Existing AI competency frameworks for K-12 teachers can serve as a guide for further designing and adapting frameworks and professional development activities for faculty in higher education. For example, the UNESCO AI Competency Framework includes five AI-related aspects (human-centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional development) at three levels of progression (acquire, deepen, create) (UNESCO, 2024b).

By engaging faculty, students, administrators, and other stakeholders in discussions about AI, higher education institutions can develop a more cohesive and forward-thinking approach to digital transformation. One innovative approach to encouraging and recognizing the efforts of faculty in this digital transformation journey might be the introduction of digital badges/micro-credentials and micro-degrees (European Commission, 2020; Oliver et al., 2021; Varadarajan et al., 2023). On the one hand, these badges would demonstrate the professional development achievements of lecturers, and on the other hand, they would recognize their efforts to actually integrate AI into their teaching practices. Through their introduction, they would foster a culture of continuous learning and adaptation that is essential in the rapidly evolving field of AI. In conclusion, this study is an important step in understanding and enhancing the role of faculty in relation to AI in higher education, allowing for more nuanced discussion and action to support faculty in navigating the challenges and opportunities of AI. As higher education institutions continue to evolve in the digital age, it is imperative that they consider the insights from this research to foster environments in which AI is used effectively, ethically, and inclusively in educational contexts.

Future research directions might address a mixed-methods approach, beginning with qualitative interviews with faculty members. Such interviews would provide in-depth insights into their perspectives on AI in higher education. The qualitative data collected would inform the development of a new or adapted survey instrument suitable for application to a larger sample size. This approach would yield more comprehensive data, allowing for a more nuanced understanding of the impact and reception of AI in educational settings and, further, might also validate the identified profiles. In addition, such future work would build on the foundation laid by this initial study and related work, including previous qualitative research on the perspectives of academic staff (Mah & Ifenthaler, 2017).

Acknowledgements
Not applicable.

Author contributions
DM: conception, design of the work, acquisition, analysis, interpretation of data, drafted the work, Approved the submitted version (and any substantially modified version that involves the author's contribution to the study); Agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. NG: acquisition, analysis, interpretation of data, substantively revised. Approved the submitted version (and any substantially modified version that involves the author's contribution to the study); Agreed both to be personally accountable for the author's own

contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately.

Funding
Not applicable.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare that they have no competing interests.

Received: 17 June 2024 / Accepted: 9 October 2024
Published online: 17 October 2024

References

Ajzen, I. (2002). Perceived behavioral control, Self-Efficacy, Locus of Control, and the theory of planned Behavior1. *Journal of Applied Social Psychology*, *32*(4), 665–683. https://doi.org/10.1111/J.1559-1816.2002.TB00236.X

Almatrafi, O., Johri, A., & Lee, H. (2024). A systematic review of AI literacy conceptualization, constructs, and implementation and assessment efforts (2019–2023). *Computers and Education Open*, *6*. https://doi.org/10.1016/J.CAEO.2024.100173

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://psycnet.apa.org/fulltext/1977-25733-001.pdf?auth_token=3b8119f5e21dff864ebd5b9fdd961c99bb2a675a &returnUrl=https%3A%2F%2Fpsycnet.apa.org%2Frecord%2F1977-25733-001.

Bećirović, S. (2023). Digital Pedagogy. The Use of Digital Technologies in Contemporary Education. *Springer Nature Singapore*. https://doi.org/10.1007/978-981-99-0444-0

Bichler, S., Gerard, L., Bradford, A., & Linn, M. C. (2021). Designing a remote professional development course to support teacher customization in science. *Computers in Human Behavior*, *123*. https://doi.org/10.1016/J.CHB.2021.106814

Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W., & Siemens, G. (2023). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, *21*(1), 4. https://doi.org/10.1186/s41239-023-00436-z

Broadbent, J., Ajjawi, R., Bearman, M., Boud, D., & Dawson, P. (2023). Beyond emergency remote teaching: Did the pandemic lead to lasting change in university courses? *International Journal of Educational Technology in Higher Education*, *20*(1), 58. https://doi.org/10.1186/s41239-023-00428-z

Celik, I. (2023a). Exploring the Determinants of Artificial Intelligence (AI) Literacy: Digital Divide, Computational Thinking, Cognitive Absorption. *Telematics and Informatics*, *83*. https://doi.org/10.1016/J.TELE.2023.102026

Celik, I. (2023b). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, *138*. https://doi.org/10.1016/j.chb.2022.107468

Celik, I., Dindar, M., Muukkonen, H., & Järvelä, S. (2022). The promises and Challenges of Artificial Intelligence for Teachers: A systematic review of Research. *TechTrends*, *66*(4), 616–630. https://doi.org/10.1007/s11528-022-00715-y

Chan, C. K. Y., & Colloton, T. (2024). *Generative AI in Higher Education. The ChatGPT Effect*. Routledge. https://www.researchgate.net/publication/378885262_Generative_AI_in_Higher_Education_The_ChatGPT_Effect/fulltext/65f0526d32321b2cff682b6e/Generative-AI-in-Higher-Education-The-ChatGPT-Effect.pdf

Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/S41239-023-00411-8/TABLES/5

Chiu, T. K. F. (2023). The impact of generative AI (GenAI) on practices, policies and research direction in education: A case of ChatGPT and Midjourney. *Interactive Learning Environments*, 1–17. https://doi.org/10.1080/10494820.2023.2253861

Chiu, T. K. F., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, *4*, 100118. https://doi.org/10.1016/J.CAEAI.2022.100118

Chiu, T. K. F., Ahmad, Z., Ismailov, M., & Sanusi, I. T. (2024). What are artificial intelligence literacy and competency? A comprehensive framework to support them. *Computers and Education Open*, *6*. https://doi.org/10.1016/J.CAEO.2024.100171

Choi, G. W., Kim, S. H., Lee, D., & Moon, J. (2024). Utilizing generative AI for Instructional Design: Exploring strengths, weaknesses, opportunities, and threats. *TechTrends*, *68*(4), 832–844. https://doi.org/10.1007/S11528-024-00967-W/FIGURES/6

Cobo-Rendón, R., Bruna Jofre, C., Lobos, K., Cisternas San Martin, N., & Guzman, E. (2022). Return to University classrooms with blended learning: A possible post-pandemic COVID-19 scenario. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.957175

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education*, *20*(1), 22. https://doi.org/10.1186/s41239-023-00392-8

Crompton, H., & Burke, D. (2024). The Educational affordances and challenges of ChatGPT: State of the field. *TechTrends*, *68*(2), 380–392. https://doi.org/10.1007/S11528-024-00939-0/FIGURES/4

Delcker, J., Heil, J., Ifenthaler, D., Seufert, S., & Spirgi, L. (2024). First-year students AI-competence as a predictor for intended and de facto use of AI-tools for supporting learning processes in higher education. *International Journal of Educational Technology in Higher Education*, *21*(1), 1–13. https://doi.org/10.1186/S41239-024-00452-7

Eickelmann, B., Drossel, K., & Heldt, M. (2021). ICT in teacher education and ICT-related teacher professional development in Germany. *Quality in Teacher Education and Professional Development: Chinese and German Perspectives*, 107–123. https://doi.org/10.4324/9781003197973-8

European Commission (2020). *A European approach to micro-credentials*. https://education.ec.europa.eu/education-levels/higher-education/micro-credentials

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Fütterer, T., Steinhauser, R., Zitzmann, S., Scheiter, K., Lachner, A., & Stürmer, K. (2023). Development and validation of a test to assess teachers' knowledge of how to operate technology. *Computers and Education Open*, *5*, 100152. https://doi.org/10.1016/j.caeo.2023.100152

Fütterer, T., Fischer, C., Alekseeva, A., Chen, X., Tate, T., Warschauer, M., & Gerjets, P. (2023a). ChatGPT in education: Global reactions to AI innovations. *Scientific Reports*, *13*(1), 15310. https://doi.org/10.1038/s41598-023-42227-6

Gašević, D. (2023). Empowering learners for the age of artificial intelligence. *Computers and Education: Artificial Intelligence*. https://doi.org/10.1016/j.caeai.2023.100130. 4.

Gimpel, H., Hall, K., Decker, S., Eymann, T., Lämmermann, L., Mädche, A., Rödlinger, M., Ruiner, C., Schoch, M., Schoop, M., Urbach, N., & Vandrik, S. (2023). *Unlocking the Power of Generative AI Models and Systems such as GPT-4 and ChatGPT for Higher Education Unlocking the Power of Generative AI Models and Systems such as GPT-4 and ChatGPT for Higher Education* (p. 47). University of Hohenheim. https://digital.uni-hohenheim.de/fileadmin/einrichtungen/digital/Generative_AI_and_ChatGPT_in_Higher_Education.pdf

Grassini, S. (2023). Shaping the future of education: Exploring the potential and consequences of AI and ChatGPT in Educational Settings. *Education Sciences*, *13*(7). https://doi.org/10.3390/educsci13070692

Hodges, C. B., & Kirschner, P. A. (2024). Innovation of Instructional Design and Assessment in the age of Generative Artificial Intelligence. *TechTrends*, *68*(1), 195–199. https://doi.org/10.1007/s11528-023-00926-x

Hornberger, M., Bewersdorff, A., & Nerdel, C. (2023). What do university students know about Artificial Intelligence? Development and validation of an AI literacy test. *Computers and Education: Artificial Intelligence*. https://doi.org/10.1016/J.CAEAI.2023.100165. *5*.

IBM Corp. (2021). *IBM SPSS statistics for Windows (28.0)*. IBM Corporation.

Ifenthaler, D. (2017). Are higher Education Institutions prepared for Learning Analytics? *TechTrends*, *61*(4), 366–371. https://doi.org/10.1007/s11528-016-0154-0

Ifenthaler, D., & Yau, J. Y. K. (2019). Higher education stakeholders' views on learning Analytics Policy recommendations for supporting Study Success. *International Journal of Learning Analytics and Artificial Intelligence for Education (IJAI)*, *1*(1), 28–42. https://doi.org/10.3991/IJAI.V1I1.10978

Ifenthaler, D., Majumdar, R., Gorissen, P., Judge, M., Mishra, S., Raffaghelli, J., & Shimada, A. (2024). Artificial Intelligence in Education: Implications for policymakers, researchers, and practitioners. *Technology Knowledge and Learning*. https://doi.org/10.1007/s10758-024-09747-0

Johnston, H., Wells, R. F., Shanks, E. M., Boey, T., & Parsons, B. N. (2024). Student perspectives on the use of generative artificial intelligence technologies in higher education. *International Journal for Educational Integrity*, *20*(1), 1–21. https://doi.org/10.1007/S40979-024-00149-4/TABLES/10

Joksimovic, S., Ifenthaler, D., Marrone, R., De Laat, M., & Siemens, G. (2023). Opportunities of artificial intelligence for supporting complex problem-solving: Findings from a scoping review. *Computers and Education: Artificial Intelligence*, *4*. https://doi.org/10.1016/J.CAEAI.2023.100138

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, *103*, 1–13. https://doi.org/10.1016/j.lindif.2023.102274

Kaya, F., Aydin, F., Schepman, A., Rodway, P., Yetişensoy, O., & Kaya, D., M (2024). The roles of personality traits, AI anxiety, and demographic factors in attitudes toward Artificial Intelligence. *International Journal of Human–Computer Interaction*, *40*(2), 497–514. https://doi.org/10.1080/10447318.2022.2151730

Kohnke, L., Moorhouse, B. L., & Zou, D. (2023). Exploring generative artificial intelligence preparedness among university language instructors: A case study. *Computers and Education: Artificial Intelligence*. https://doi.org/10.1016/j.caeai.2023.100156. *5*.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121–1134.

Langeheine, R., & Rost, J. (1996). Latent-Class-Analyse. In *Handbuch quantitative methoden*. *Universitätsbibliothek Mannheim*, 315–332. https://doi.org/10.25521/HQM25

Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial intelligence literacy in higher and adult education: A scoping literature review. *Computers and Education: Artificial Intelligence*, *3*, 100101. https://doi.org/10.1016/j.caeai.2022.100101

Law, L. (2024). Application of generative artificial intelligence (GenAI) in language teaching and learning: A scoping literature review. *Computers and Education Open*, *6*. https://doi.org/10.1016/J.CAEO.2024.100174

Lintner, T. (2024). A systematic review of AI literacy scales. *Npj Science of Learning*, *9*. https://doi.org/10.1038/s41539-024-00264-4

Liu, Q., Geertshuis, S., & Grainger, R. (2020). Understanding academics' adoption of learning technologies: A systematic review. *Computers & Education*, *151*, 103857. https://doi.org/10.1016/J.COMPEDU.2020.103857

Lo, Y., Mendell, N. R., & Rubin, D. B. (2001). Testing the number of components in a normal mixture. *Biometrika*, *88*(3), 767–778. https://doi.org/10.1093/BIOMET/88.3.767

Long, D., & Magerko, B. (2020). What is AI Literacy? Competencies and Design Considerations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–16. https://doi.org/10.1145/3313831.3376727

Luckin, R., Cukurova, M., Kent, C., & Du Boulay, B. (2022). Empowering educators to be AI-ready. *Computers and Education: Artificial Intelligence*, *3*. https://doi.org/10.1016/j.caeai.2022.100076

Mah, D. K. (2023, June 3). *Beyond the hype: Integrating ChatGPT and co. into university teaching | AI Campus*. https://ki-campus.org/blog/chatgpt-hochschullehre?locale=en

Mah, D. K., & Ifenthaler, D. (2017). Academic staff perspectives on first-year students' academic competencies. *Journal of Applied Research in Higher Education*.

Mao, J., Chen, B., & Liu, J. C. (2023). Generative Artificial Intelligence in Education and its implications for Assessment. *TechTrends*. https://doi.org/10.1007/s11528-023-00911-4

Márquez, L., Henríquez, V., Chevreux, H., Scheihing, E., & Guerra, J. (2023). Adoption of learning analytics in higher education institutions: A systematic literature review. *British Journal of Educational Technology*. https://doi.org/10.1111/bjet.13385

McCarthy, A. M., Maor, D., McConney, A., & Cavanaugh, C. (2023). Digital transformation in education: Critical components for leaders of system change. *Social Sciences & Humanities Open*, *8*(1), 100479. https://doi.org/10.1016/j.ssaho.2023.100479

McGrath, C., Cerratto Pargman, T., Juth, N., & Palmgren, P. J. (2023). University teachers' perceptions of responsibility and artificial intelligence in higher education - an experimental philosophical study. *Computers and Education: Artificial Intelligence*, *4*. https://doi.org/10.1016/J.CAEAI.2023.100139

Meyer, A., Kleinknecht, M., & Richter, D. (2023). What makes online professional development effective? The effect of quality characteristics on teachers' satisfaction and changes in their professional practices. *Computers & Education*, *200*, 104805. https://doi.org/10.1016/J.COMPEDU.2023.104805

Mishra, P., Warr, M., & Islam, R. (2023). TPACK in the age of ChatGPT and Generative AI. *Journal of Digital Learning in Teacher Education*, *39*(4), 235–251. https://doi.org/10.1080/21532974.2023.2247480

Mohamed Hashim, M. A., Tlemsani, I., & Matthews, R. (2022). Higher education strategy in digital transformation. *Education and Information Technologies*, *27*(3), 3171–3195. https://doi.org/10.1007/s10639-021-10739-1

Mollick, E. R., & Mollick, L. (2024). Instructors as innovators: A future-focused Approach to New AI Learning opportunities, with prompts. *SSRN Electronic Journal*. Elsevier BV. https://doi.org/10.2139/SSRN.4802463

Moorhouse, B. L., Yeo, M. A., & Wan, Y. (2023). Generative AI tools and assessment: Guidelines of the world's top-ranking universities. *Computers and Education Open*, *5*, 100151. https://doi.org/10.1016/j.caeo.2023.100151

Mulaimović, N., Richter, E., Lazarides, R., & Richter, D. (2024). Comparing quality and engagement in face-to-face and online teacher professional development. *British Journal of Educational Technology*, *00*, 1–19. https://doi.org/10.1111/BJET.13480

Muthén, L. K., & Muthén, B. O. (2019). *MPlus* (8.3).

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, *2*. https://doi.org/10.1016/j.caeai.2021.100041

Ng, D. T. K., Wu, W., Leung, J. K. L., Chiu, T. K. F., & Chu, S. K. W. (2023). Design and validation of the AI literacy questionnaire: The affective, behavioural, cognitive and ethical approach. *British Journal of Educational Technology*. https://doi.org/10.1111/bjet.13411

Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W., & Chu, S. K. W. (2023a). Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world. *Educational Technology Research and Development*, *71*(1), 137–161. https://doi.org/10.1007/s11423-023-10203-6

Nguyen, A., Ngo, H. N., Hong, Y., Dang, B., & Nguyen, B. P. T. (2023). Ethical principles for artificial intelligence in education. *Education and Information Technologies*, *28*(4), 4221–4241. https://doi.org/10.1007/S10639-022-11316-W/TABLES/1

Oliver, B., Beven, P., Dodd, J., Donegan, D., Healy, J., Lilly, M., Milligan, S., Pattison, P., Pope, M., Pridmore, B., Robertson, C., Sankey, M., Selvaratnam, R., Tynan, B., Williams, T., & Young, S. (2021). *National Microcredentials Framework*. https://www.education.gov.au/higher-education-publications/resources/national-microcredentials-framework

Ouyang, F., Zheng, L., & Jiao, P. (2022). Artificial intelligence in online higher education: A systematic review of empirical research from 2011 to 2020. *Education and Information Technologies*, *27*(6), 7893–7925. https://doi.org/10.1007/s10639-022-10925-9

Pinski, M., & Benlian, A. (2024). AI literacy for users – A comprehensive review and future research directions of learning methods, components, and effects. *Computers in Human Behavior: Artificial Humans*, *2*(1), 100062. https://doi.org/10.1016/J.CHBAH.2024.100062

Pratschke, B. M. (2024). *Generative AI and education*. Springer Cham. https://doi.org/10.1007/978-3-031-67991-9

Preiß, J., Bartels, M., Niemann-Lenz, J., Pawlowski, J., & Schnapp, K. U. (2023). *ChatGPT and me Erste Ergebnisse der quantitativen Auswertung einer Umfrage über die Lebensrealität mit generativer KI an der Universität Hamburg*. https://doi.org/10.25592/UHHFDM.13403

Prinsloo, P., & Slade, S. (2017). An elephant in the learning analytics room - The obligation to act. *ACM International Conference Proceeding Series*, 46–55. https://doi.org/10.1145/3027385.3027406

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. *Joint Research Centre (JRC) Science for Policy Report*, *95*. https://doi.org/10.2760/159770

Sanusi, I. T., Ayanwale, M. A., & Tolorunleke, A. E. (2024). Investigating pre-service teachers' artificial intelligence perception from the perspective of planned behavior theory. *Computers and Education: Artificial Intelligence*, *6*, 100202. https://doi.org/10.1016/j.caeai.2024.100202

Schepman, A., & Rodway, P. (2023). The General attitudes towards Artificial Intelligence Scale (GAAIS): Confirmatory Validation and associations with personality, corporate distrust, and General Trust. *International Journal of Human–Computer Interaction*, *39*(13), 2724–2741. https://doi.org/10.1080/10447318.2022.2085400

Schmid, R. F., Borokhovski, E., Bernard, R. M., Pickup, D. I., & Abrami, P. C. (2023). A meta-analysis of online learning, blended learning, the flipped classroom and classroom instruction for pre-service and in-service teachers. *Computers and Education Open*, *5*, 100142. https://doi.org/10.1016/j.caeo.2023.100142

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (track): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, *42*(2), 123–149. https://doi.org/10.1080/15391523.2009.10782544

Singh, J., Steele, K., & Singh, L. (2021). Combining the best of online and face-to-face learning: Hybrid and blended Learning Approach for COVID-19, Post Vaccine, & Post-pandemic World. *Journal of Educational Technology Systems*, *50*(2), 140–171. https://doi.org/10.1177/00472395211047865

Southworth, J., Migliaccio, K., Glover, J., Glover, J., Reed, D., McCarty, C., Brendemuhl, J., & Thomas, A. (2023). Developing a model for AI across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education: Artificial Intelligence*, *4*. https://doi.org/10.1016/j.caeai.2023.100127

Stanford University (2024). *Introduction to the AI Index Report 2024*. https://aiindex.stanford.edu/wp-content/uploads/2024/04/HAI_AI-Index-Report-2024.pdf

Strzelecki, A. (2023). Students' Acceptance of ChatGPT in Higher Education: An extended Unified Theory of Acceptance and Use of Technology. *Innovative Higher Education*, 1–23. https://doi.org/10.1007/S10755-023-09686-1/TABLES/4

Tsai, Y. S., Rates, D., Moreno-Marcos, P. M., Muñoz-Merino, P. J., Jivet, I., Scheffel, M., Drachsler, H., Delgado Kloos, C., & Gašević, D. (2020). Learning analytics in European higher education—trends and barriers. *Computers & Education*, *155*. https://doi.org/10.1016/j.compedu.2020.103933

UNESCO (2023). *Guidance for generative AI in education and research*. https://unesdoc.unesco.org/ark:/48223/pf0000386693

UNESCO (2024a). *AI competency framework for students*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000391105

UNESCO (2024b). *AI competency framework for teachers*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000391104

Varadarajan, S., Koh, J. H. L., & Daniel, B. K. (2023). A systematic review of the opportunities and challenges of micro-credentials for multiple stakeholders: Learners, employers, higher education institutions and government. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/S41239-023-00381-X/FIGURES/3

Venkatesh, V., & Davis, F. D. (2000). *A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies* (Vol. 46, Issue 2). https://www.jstor.org/stable/2634758?seq=5

von Garrel, J., & Mayer, J. (2023). Artificial Intelligence in studies—use of ChatGPT and AI-based tools among students in Germany. *Humanities and Social Sciences Communications*, *2023 10:1*(10(1)), 1–9. https://doi.org/10.1057/s41599-023-02304-7

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). DigComp 2.2: The Digital competence Framework for citizens. *European Commission*. https://doi.org/10.2760/115376

Wang, Y. Y., & Chuang, Y. W. (2024). Artificial intelligence self-efficacy: Scale development and validation. *Education and Information Technologies*, *29*(4), 4785–4808. https://doi.org/10.1007/S10639-023-12015-W/TABLES/8

Wang, B., Rau, P. L. P., & Yuan, T. (2023). Measuring user competence in using artificial intelligence: Validity and reliability of artificial intelligence literacy scale. *Behaviour and Information Technology*, *42*(9), 1324–1337. https://doi.org/10.1080/0144929X.2022.2072768

Xia, Q., Weng, X., Ouyang, F., Lin, T. J., & Chiu, T. K. F. (2024). A scoping review on how generative artificial intelligence transforms assessment in higher education. *International Journal of Educational Technology in Higher Education*, *21*(1), 1–22. https://doi.org/10.1186/S41239-024-00468-Z/TABLES/2

Xie, J., A, G., & Rice, M. F. (2021). Instructional designers' roles in emergency remote teaching during COVID-19. *Distance Education*, *42*(1), 70–87. https://doi.org/10.1080/01587919.2020.1869526

Yusuf, A., Pervin, N., Román-González, M., & Noor, N. M. (2024). Generative AI in education and research: A systematic mapping review. *Review of Education*, *12*(2). https://doi.org/10.1002/REV3.3489

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0

Zawacki-Richter, O., Bai, J. Y. H., Lee, K., van Tryon, S., P. J., & Prinsloo, P. (2024). New advances in artificial intelligence applications in higher education? *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/S41239-024-00464-3/METRICS

Zheng, L., Fan, Y., Gao, L., Huang, Z., Chen, B., & Long, M. (2024). Using AI-empowered assessments and personalized recommendations to promote online collaborative learning performance. *Journal of Research on Technology in Education*. https://doi.org/10.1080/15391523.2024.2304066

Publisher's note

Prof. Dr. Dana-Kristin Mah is Junior Professor for Digital Teaching and Learning at the Institute of Educational Sciences at Leuphana University of Lüneburg, Germany. Her current research interests are particularly in the area of higher education with a focus on educational technologies, artificial intelligence, learning analytics, instructional design, and competencies. Her previous positions include academic researcher at the University of Potsdam, TU Berlin, and AI Campus – the learning platform for artificial intelligence. She received her PhD from the University of Mannheim, Germany. For more information see: https://www.leuphana.de/en/institutes/ibiwi/team/dana-kristin-mah.html.

Nele Groß graduated from the University of Hamburg with a master's degree in educational science with a focus on special education. She completed her doctoral studies at the University of Hamburg as part of the JeKi research project on the impact and long-term effects of music programs. She is currently a research assistant at the Leuphana University of Lüneburg, Germany. She works in the Department of Educational Science, specializing in educational management and quality development. Her research focuses include educational health research, higher education didactics, (digital) teaching and learning, empiric educational research, and data-driven school and classroom research. For more information see https://www.leuphana.de/institute/ibiwi/personen/nele-gross.html.