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Article

Artificial intelligence and the modelling of teachers' competencies

Amfiteatru Economic

Provided in Cooperation with:
The Bucharest University of Economic Studies

Suggested Citation: Simuț, Ramona; Simuț, Ciprian; Bădulescu, Daniel; Bădulescu, Alina (2024) : Artificial intelligence and the modelling of teachers' competencies, Amfiteatru Economic, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 26, Iss. 65, pp. 181-200, https://doi.org/10.24818/EA/2024/65/181

This Version is available at:
https://hdl.handle.net/10419/281816

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ARTIFICIAL INTELLIGENCE AND THE MODELLING OF TEACHERS' COMPETENCIES

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Please cite this article as:
Simuț, R., Simuț, C., Bădulescu, D. and Bădulescu A., 2024. Artificial Intelligence and the Modelling of Teachers' Competencies. *Amfiteatru Economic*, 26(65), pp. 181-200.

DOI: https://doi.org/10.24818/EA/2024/65/181

Article History
Received: 29 September 2023
Revised: 21 November 2023
Accepted: 22 December 2023

Abstract
This research explores educators' perceptions of their role in shaping competencies and also presents the key challenges and measures perceived by educators in the AI system development landscape. The study employs a partial least square – structural equation modelling (PLS-SEM) as the primary analytical tool. A set of hypotheses was derived from the literature, formulated and tested to substantiate the relationship between educators' attitudes and competencies. The findings highlight a significant positive relationship between teachers' attitudes toward AI and competence development, with the most pronounced impact on educational management competencies. Thus, teachers' positive attitudes toward AI statistically significant influence cognitive, fundamental and educational management competencies, underscoring the critical role of instilling positive attitude towards AI among educators to foster the development of multifaceted competencies. Furthermore, the research highlights key challenges to integrating AI into education, including the imperative for professional development for educators and ensuring equitable access to educational resources and technology. From a practical point of view, the study advocates for initiatives aimed at bridging the digital divide and integrating AI education into curricula as indispensable policy measures. The originality of our research lies in the unitary approach of the relationship between positive attitudes of teachers toward artificial intelligence and a series of competencies, such as cognitive, fundamental and educational management. Although the study provides valuable information, it has certain limitations. The findings are based on educators' perceptions and attitudes, which may vary among individuals, the study scope is limited to a specific region, and the generalisability of findings to other settings may require further investigation. This research contributes to the existing literature by exploring the relationship between teachers' attitudes toward AI and the development of their skills, with the help of an exploratory model using structural equations, a model that has the teachers in the foreground.

Keywords: Artificial intelligence (AI), educator, competencies, attitude.
JEL Classification: A21; I21; O33

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Introduction

Artificial intelligence (AI) refers to the ability of a digital machine to perform tasks by imitating human intelligence, to learn and think (Xia et al., 2022; Chiu et al., 2023), to solve problems and make decisions (Bellman, 1978), to do something that would normally be thought to require the intelligence of a human (Mitchell, 2019), or "machines with minds, in the full and literal sense" (Haugeland, 1989).

AI has experienced an exceptional spread in recent decades, continuously changing the way people live, interact, learn and work (Chiu et al., 2022; Xia et al., 2022), even though the understanding of the place and role of AI in economic development is still fragmented (Qin et al., 2023). AI excels in the execution and improvement of specific tasks, continuously modifying and improving each economic sector, taking sound decisions (Dong et al., 2020), streamlining production processes, and strengthening the businesses in which it is present. However, the use and expansion of AI in the economy requires the development of new skills and abilities, from technological expertise to social, emotional and creative skills (Felea and Vasiliu, 2005; Pelau, Dabija and Ene, 2021; Limna et al., 2022; Klimova, Pikhart and Kacetl, 2023) suggesting the vital relationship between AI and education, full of unexplored development possibilities.

In the existing literature, the predominant focus has been on examining students' views on the connection between AI and competencies within their scope and less on teachers' competencies in developing AI. However, this study shifts the focus to educators and their role in shaping competencies in the context of AI development. Therefore, the aim of this research is to investigate the perception of teachers regarding the role of educators in modelling competencies in the context of the development of artificial intelligence systems by employing an exploratory model, using structural equation modelling. These competencies, in turn, serve as vital tools for educators in educating students about AI's evolution.

In this paper, we will refer to AI applications that are freely available on dedicated educational platforms or are developed by companies focused on education. These applications can be used by both teachers and students to develop new skills. The paper is structured as follows: theoretical background regarding the role and expansion of AI in education, respectively, the role of educators in modelling competencies in AI, methodology, results and discussion, conclusions and policy implications.

1. Theoretical background

AI in education energises the evolution of teaching and learning practices and the modernisation of programmes, being at the same time a fruitful topic for the progress of educational research. All these reasons and promises offered by AI in education determined numerous initiatives and clarifications at the national decision-maker level, or within international institutions (UNESCO, 2019; OECD, 2021; European Commission, 2022). The increased attention given to this field has revealed, however, that much of the research has focused more on engineering aspects (algorithms, machine learning techniques), on educational technologies (gamification, blended learning) and less on the impact of AI on education. For many researchers, this impact is still unclear (Miao et al., 2021), and the limited training and experiences of teachers and managers

make it difficult to introduce and integrate AI into the education system (Hussin, 2018; Owoc, Sawicka and Weichbroth, 2021).

According to Chiu et al. (2023) the potential of AI in education is huge: it can improve learning activities by making them more personalised and adaptable; supports teaching by encouraging them to understand students' learning process, providing anywhere and anytime prompts interrogations and feedback; improves the evaluation processes and administrative activities at the level of educational institutions (Luckin, 2017; González-Calatayud, Prendes-Espinosa and Roig-Vila, 2021). AI is one of the key technologies prepared to revolutionize education (Talan, 2021), to transform the traditionalist and somewhat rigid way in which education is perceived and delivered, adapting it to the technological advances of the modern world (Sadiku et al., 2021).

1.1. Concerns about the role and expansion of AI in education

Concerns and concerns about the impact of AI on education systems and society in general are numerous and it would be superficial to categorise them only as prejudices and misconceptions (European Commission, 2022). Some of them even seem serious once they have led many education specialists and experts to ask for a "pause" in the development of AI (Future of Life Institute, 2023; Malekos, 2023).

The first concern focusses on *(1) the difficulty of understanding AI*. The lack of knowledge in computer science, the complicated and sometimes abstract terminology, and the pace of news overlap with the real difficulties of understanding the inside workings of the AI system. The lack of technological knowledge on the part of educators (Chiu and Chai, 2020) is often exacerbated by the technical infrastructure in schools, often insufficient to support the implementation of AI in educational processes (McCarthy et al., 2016; Ozdemir and Tekin, 2016).

The second concern and misunderstanding is that *(2) AI has a limited or no real role in education*. The implementation of AI in education may be affected by the lack of interest of teachers in AI, they may perceive AI as "uninteresting and unenjoyable for teaching" (McCarthy et al., 2016; Celik et al., 2022), or that AI algorithms are not sufficiently predictable and adapted to their practical needs (Schwarz et al., 2018; Qian, Zhao and Cheng, 2020). However, AI is continuously changing the way we work and live, and education cannot stay away from these changes. It is important that everyone benefits from these changes and to be part of them, and that AI systems and solutions in education "to be developed and used in an ethical, trustworthy, fair and inclusive way" (European Commission, 2022, p. 12).

Another problem is that *(3) AI is not inclusive*. It can aggravate inequality, discrimination, or give birth to new forms of inequality and segregation (UNESCO, 2019; European Commission, 2022). Experts note the possibility that (biased) algorithms in AI applications used to evaluate student performance could alter the principles of accuracy and objectivity on the basis of which they were created and promoted, favouring students who attended private or well-rated schools, while students from under-represented groups may be more affected (Akgun and Greenhow, 2022). AI-based scoring may sometimes imperfectly assess students' performance (Lu, 2019) and can undermine teachers' confidence in their accuracy (Qian, Zhao and Cheng, 2020). Perpetuating and validating these biased constructs can affect students' (official) performance, self-confidence, and their future careers.

Another objection relates to *(4) trust issues in AI systems*, that their rapid, universal development and spread will lead to the replacement of human decisions in more and more contexts, increasing the risks of a lack of ethical considerations. Akgun and Greenhow (2022) consider privacy, surveillance, autonomy, bias, and discrimination to be the most important ethical challenges of AI applications in education. Seen also as a surveillance system, AI is alleged of generating problems related to personal autonomy, affecting the ability to judge and act based on one's own interests and values, for both students and teachers (Regan and Jesse, 2019). Algorithms that predict future actions based on collected information raise questions about fairness and self-freedom (Akgun and Greenhow, 2022), and increase the risks of perpetuating existing prejudices, discriminations and maintaining social stratification (Murphy, 2019). The regulation of AI will therefore require public discussions regarding ethics, responsibility, and security such as algorithmic bias, data privacy, content ownership, and transparency (UNESCO, 2019; Malekos, 2023). Researchers support ethical approaches more sensitive to context and pedagogy (Adams et al., 2023), cooperation and joint research involving other stakeholders when it comes to the ethical implications of using AI–in education.

Another caution, specific to education, comes from the supposition that *(5) AI will undermine the role of the teacher and make him/her obsolete and useless*. Fear is difficult to ignore and can be real if educators and authorities in the field do not properly assimilate and understand the use and impact of AI in education. For Dillenbourg (2016) or Hrastinski et al. (2019), teacherless education is an overly pessimistic and speculative view, and they recommend insisting on understanding the opportunities that AI offers to teachers and how these advantages can change the roles of teachers in the classroom (Celik et al., 2022). Individual efforts and institutional support are needed to understand that AI helps and complements the efforts of teachers, generates learning experiences, encourages students' creativity and free thinking and challenges them to solve real-world problems. However, this AI support cannot be achieved outside of an authentic human framework of the educator, because AI projects are tools created to support and strengthen the role of the educator rather than replace it (Moisil et al., 2010; Pinkwart, 2016; Schiff, 2021). In the logical dismantling of this concern, comes the argument that AI can simplify and ease administrative tasks (quite substantial in education systems) allowing educators to focus more and more efficiently on the educational process, to have time to adapt to new transformations, and implicitly "the role of the teacher is likely to be augmented and evolve with the capabilities that new innovations for AI in education will bring" (European Commission, 2022, p. 13). According to Holstein et al. (2019), AI-based machines can support and complement educators to fulfil their unique role of "orchestrator" in the learning and teaching process (Dillenbourg, 2013), but the effectiveness of teaching depends on the ability of teachers to accept and assimilate appropriate pedagogical methods in their training (Tondeur et al., 2020), to learn from errors and from the difficulties of the beginning (Prieto et al., 2018).

This concern seems to be related to the concern of *(6) Lack of Human Interaction*, the isolation and disconnection of students from peers, teachers and social interactions is often explained by excessive (sometimes destructive) reliance on AI and the artificial substitution of genuine social contexts. However, with all the informational and educational contribution of AI, it cannot substitute and replace "human interaction and the social and emotional learning that comes with it" (Malekos, 2023).

Finally, *(7) Content saturation*, along with *developing lazy minds and the lack of critical thinking* (Malekos, 2023) is another problem raised. The concern is not only about education, "AI significantly impacts the loss of human decision making and makes humans lazy" (Ahmad et al., 2023), it diminishes intuitive analysis and creative problem solving, autonomy, replacing human decision with its choices (Danaher, 2018). Thus, it is argued that AI does not simplify, but increases the amount of information, often un-systematised and biased, and this can lead to fatigue and demotivation, decreasing learning performance. This situation stimulates lazy minds, disinterest and the "complicity" of an uncritical thinking, lacking the tools and reasoning against misinformation and manipulation. Although there are assessments that these tendencies are blurred when AI is complementary and used as a support and assistant to the teaching done by a real educator, they should not be ignored.

1.2. The role of educators in modelling competencies in AI

AI and education are a topic of significant interest for researchers, Mena-Guacas et al. (2023) found a rise in the literature on the subject of developing competencies through collaboration. In the context of student-to-student and AI collaboration, Li and Su (2020) argue that physical meetings among students are of great importance, despite computer-mediated interactions made human connections more accessible. Furthermore, research on cognitive, communicative, collaborative, and generic competencies is also of great interest in the field of AI and education. As Vinichenko, Melnichuk and Karácsony (2020) argue the issue of AI development that enables student efficiency, focusses on collective and individual performance analysis, information for decision making, and providing tools for diagnostic and predictive analysis, especially in a context where students are tempted to use AI to cheat in their assignments.

Lameras and Arnab (2022) found that there is a need to rationalise and delineate the extent to which AI can be inserted and used in education. It seems of great importance to consider the way in which evaluation tools, various instructional strategies, ethical implications and teacher competencies (digital, cognitive, fundamental, and in educational management) are designed, developed, and applied in educational settings (Ng et al., 2021). The means through which AI would operate in these settings is to transform educational, psychological, and social knowledge into computational language. This would allow AI to interpret data and translate it in order to support, guide, and enhance student learning and the ability to think in a more efficient way (Kim, Lee and Cho, 2022; Sobolu, Stanca and Bodog, 2023). The result would be technological innovation through activity-based, adaptive, and student-oriented strategies.

AI would also allow for a deeper understanding of the mechanics of education, through an increasingly precise analysis of student knowledge, assessment, and feedback. AI is primarily focused on helping students, but the teacher factor must also be taken into account. Vlasova et al. (2019) show that one of the main issues is that, without proper and consistent training, teachers might be overwhelmed by the complexity of AI educational tools that they are to use in teaching. Also, Zhao, Guo and Liu (2021) suggest customised teacher training programmes aligned with the local context to guide teachers to consciously improve their professional development, in order to create professional competencies among teachers. The solution could be a careful re-evaluation and reorganisation of AI education tools that would be used in a contextualised manner, adapted for each classroom situation (Touretzky et al., 2019).

Polak, Schiavo and Zancanaro (2022) argue that AI can be used to develop citizenship skills, in order to help students become responsible and confident, in maneuvering in an ever increasingly difficult and complex digital world. Alexandre et al. (2021) found that teachers' perspectives on AI and its use in educational settings were positive, willing and supportive of using AI, despite having limited AI-related competencies (Chounta et al., 2022). It seems that digital skills are not considered sufficient by teachers to use in AI-related educational issues (Ng et al., 2023). However, teachers argued that in order to have an efficient AI educational structure, there need to be various teacher training programmes that would provide basic AI related skills and knowledge, relevant AI content to use in school settings, connected to interactive and collaborative methods of teaching, accessible software and hardware, and user motivation initiatives (Vlasova et al., 2019).

On the issue of student competencies in AI education, Sanusi et al. (2022b) determined that cognitive, human tool collaboration, self-learning, skill competence, and ethics were significantly influencing AI content. Of significant importance, as Sanusi et al. (2022a) was the discovery that teamwork competence and AI curriculum need to be improved. Kim and Kwon (2023) incorporate empirical observations originating from educators' direct participation in the implementation of AI curricula within their class settings. This method provides a holistic perspective that encompasses both the cognitive and emotional aspects of their abilities. Huang (2021) showed that to efficiently accommodate AI course content, such as programming knowledge, image processing knowledge, natural language processing knowledge, ethics of artificial intelligence and machine learning, students need to develop several key competencies, such as skill and cultural competencies, teamwork and human-tool collaboration competencies, cognition and self-learning competencies.

Pedro et al. (2019) tackle the issue of the challenges AI poses to the general field of education, such as comprehensive public policy on AI, but in the context of sustainable development, inclusion and equity in AI, teacher training for AI-powered education, but also preparing AI to understand education, the need for the development of quality and inclusive data systems, implementation of significant AI research for education, and ethics and transparency in data collection, but also in the use and dissemination. In such a context, teachers with a positive perspective about AI in educational environments are more willing to develop the cognitive, digital, fundamental, and educational management competencies.

Based on our theoretical framework and insights identified in previous research (Zhao, Guo and Liu, 2021; Sanusi et al., 2022a; Kim and Kwon, 2023; Ng et al., 2023), we developed a series of research hypotheses. Our fundamental premise assumes that a positive attitude toward AI exerts a generally positive influence on educators' competencies in the context of developing artificial intelligence systems. The research hypotheses are as follows.

- Hypothesis 1 (H1): The positive attitude of teachers towards AI has a positive and significant impact on cognitive competencies.
- Hypothesis 2 (H2): The positive attitude of teachers towards AI has a positive and significant impact on digital competencies.
- Hypothesis 3 (H3): The positive attitude of teachers towards AI has a positive and significant impact on educational management competencies.
- Hypothesis 4 (H4): The positive attitude of teachers towards AI has a positive and significant impact on fundamental competencies.

3. Methodology

The main objective of this research is to develop and validate an exploratory model, with the help of a structural equation, regarding the perception of teaching staff regarding the role of educators in modelling competencies in the context of the development of artificial intelligence systems. Moreover, starting from the results of the structural equation modelling (SEM), we will follow the challenges and measures that teachers consider to be the most important in the context of the development of artificial intelligence systems. Before the implementation of this questionnaire, we conducted a pilot study on a group of 20 teachers, consisting of 10 teaching staff from pre-university education and 10 from higher education institutions. This served to verify the accuracy of the questions and subsequently the questionnaire was revised according to the comments received. In carrying out the research, we used the survey method, starting from the elaboration of the questionnaire and its distribution in the on-line environment. The questionnaire comprised two sections, each consisting of closed-ended questions, was designed by using the online application Google Forms and was distributed online. The initial section of the questionnaire focused on collecting demographic information from the participants, while the subsequent section delved into specific inquiries concerning educators' roles in the context of the development of artificial intelligence systems. Data collection occurred in August 2023, resulting in a convenience sampling comprised of 138 respondents who are educators in both preuniversity and university settings within Bihor County (see Table 1). The convenience sampling, which typically relies on volunteer participants, is a widely used method in research (Maxwell and Delaney, 2004), and it is also acknowledged for its relatively lower degree of rigour. This approach does have its limitations, notably its potential to introduce bias since it does not necessarily represent the broader population. To mitigate these limitations, we employ direct email outreach for participant recruitment and implement the "snowball" technique to expand our sample size.

Table no. 1. Profile of the respondents

Characte-ristics	Category	Abs.fr.	Rel. fr. (%)	Characte-ristics	Category	Abs. fr.	Rel. fr. (%)
Gender	Male	26	20%				
	Female	111	80%				
Age	[20-30) Years	8	6%	**Work experience**	0-3 Years	10	7%
	[30-40) Years	33	24%		3-9 Years	13	9%
	[40-50) Years	58	42%		10-20 Years	45	33%
	[50-60) Years	35	25%		Over 20 years	70	51%
	60 years or older	4	3%				
Teaching level	Preschool	4	3%				
	Primary school	29	21%				
	Low secondary	15	11%	**Profile of specialisation**	Real	58	42%
	Higher secondary	44	32%		Humanistic	80	58%
	University	46	33%				
Residence	Urban	119	86%	**Teaching location**	Urban	125	91%
	Rural	19	14%		Rural	13	9%
TOTAL		**138**	**100%**	**TOTAL**		**138**	**100%**

Note: Abs. fr. – the absolute frequency, Rel. fr. – the relative frequency

Source: own contribution

The structure of the sample is presented in Table no. 1 provides a broad perspective on the aspects investigated, both through the area of specialisation in which the teacher is active and through the professional experience of the respondents. 138 Bihor County teachers participated in the study. The questionnaire that is the basis of this research contains 27 items regarding the attitude of teachers toward AI and the competencies (digital, cognitive, fundamental and educational management) they should develop in order to promote AI among students. For a unified understanding, respondents considered AI as a generic term for any educational application based on artificial intelligence that can be used in the teaching-learning process. The respondents were invited to rate the items presented in Table no. 2 using a five-point Likert scale (1 - Strongly Disagree; 5 - Strongly Agree). Additionally, the questionnaire includes 8 items related to the challenges facing education in the development of AI systems and 8 items related to a series of measures to manage the consequences of the integration of AI into society. Regarding the global score of Cronbach's Alpha, we obtained a good value of 0.890, which shows a good internal consistency of the items. The results on the subscales can be found in Table no. 2.

Table no. 2. Description of the constructs and reliability analysis

Item	Measure	Factor Loading	Cronbach's Alpha (> 0.7)	rho_A (> 0.7)	CR (> 0.8)	AVE (> 0.5)
Positive attitude of teachers towards AI (ATT) adapted from Sanusi et al. (2022a); Kim and Kwon (2023)						
ATT1	AI will help improve learning processes	0.871	0.773	0.779	0.870	0.691
ATT2	AI will help tailor learning to the individual needs of learners	0.875				
ATT3	AI will help reduce inequalities in education	0.741				
Digital competencies (DC) adapted from Ng et al. (2023); Kim and Kwon (2023)						
DC1	Competence in the use of the computer	0.905	0.971	0.979	0.977	0.875
DC2	Competencies in using the Internet	0.936				
DC3	Digital literacy	0.962				
DC4	Information literacy	0.957				
DC5	Blended learning	0.932				
DC6	Online research competencies	0.919				
Cognitive competencies (CC) adapted from Sanusi et al. (2022a); Kim and Kwon (2023)						
CC1	Critical thinking to explain complex AI concepts	0.918	0.966	0.978	0.972	0.854
CC2	Adaptability and continuous learning in relation to AI advances	0.941				
CC3	Encouraging creativity and innovative thinking in AI development	0.933				
CC4	Motivating students in AI development	0.911				

Item	Measure	Factor Loading	Cronbach's Alpha (> 0.7)	rho_A (> 0.7)	CR (> 0.8)	AVE (> 0.5)
CC5	Hands-on experience in AI development	0.920				
CC6	Correlating AI concepts with real-world applications	0.922				
Educational management competencies (EMC) adapted from Kim and Kwon (2023)						
EMC1	Implementing AI education for all age groups, from all walks of life	0.879	0.955	0.965	0.964	0.817
EMC2	Integrating AI concepts into different educational disciplines	0.914				
EMC3	Promoting a mindset of lifelong learning	0.866				
EMC4	Ensuring equitable access to AI education and resources	0.905				
EMC5	Developing AI training programmes for educators	0.937				
EMC6	Collaboration with the business environment to identify AI skills	0.919				
Fundamental competencies (FC) adapted from Kim and Kwon (2023)						
FC1	Encourage students to explore unconventional AI solutions	0.886	0.964	0.966	0.971	0.847
FC2	Promoting experimentation and risk-taking in AI projects	0.926				
FC3	Providing students with resources for AI ideas and innovations	0.937				
FC4	Mentoring students in the development of AI applications with social impact	0.934				
FC5	Stimulating brainstorming sessions of AI projects	0.932				
FC6	Presentation of successful experiences in the field of AI	0.906				

Source: own contribution

Statistical hypotheses were tested using the Partial Least Square - Structural Equation Modelling (PLS-SEM) method, and the data were analysed using the SmartPLS 3.3.9 statistical software. This method allows the identification of cause-effect relationship models even when considering a complex set of elements (Benitez et al., 2020), respectively, when we have a small sample size (Hair et al., 2017). The elements of the constructs, the attitude of teachers to AI (3 elements), digital competencies (6 elements), cognitive competencies (6 elements), fundamental competencies (6 elements) and educational management competencies (6 items) were adapted from Zhao, Guo, and Liu (2021), Sanusi et al. (2022a), Kim and Kwon (2023), Ng et al. (2023).

Regarding the examination of the reliability and validity of the items from the five constructs, Cronbach's alpha, rho_A, and composite reliability were analysed. According to the results presented in Table no. 2, all values of Cronbach's alpha and rho_A were above the recommended standard value of 0.70, and the composite reliability (CR) was above the recommended standard value of 0.80 (Cronbach and Shavelson, 2004; Chin, 2010). Therefore, the reliability of all factors analysed was established. We used the Average Variance Extracted (AVE) in order to test the discriminant validity of the model. The values of Average Variance Extracted for each construct are higher than the acceptable value of 0.50 (Chin, 2010) which confirms the discriminant validity of the proposed model.

To effectively harness the potential of AI in education, educators must understand AI technologies, adapt teaching methods, and stay abreast of ever-evolving AI advances. Therefore, the integration of AI in education is not without challenges. Starting from the results obtained following the analysis of the impact of positive attitudes toward AI on the competencies of educators, in this paper, we propose to present the challenges faced by educators and the measures proposed by them to make the potential of AI in education more efficient.

4. Results and discussion

4.1. The relationship between the positive attitude of teachers towards AI and the competencies of teachers

The structural model with path coefficient is presented in Figure no. 1. The results obtained and presented in Figure no. 1 show that within the proposed structural model, all the estimated coefficients are positive, which means that the teachers' positive attitude towards AI positively influences the 4 categories of competencies analysed.

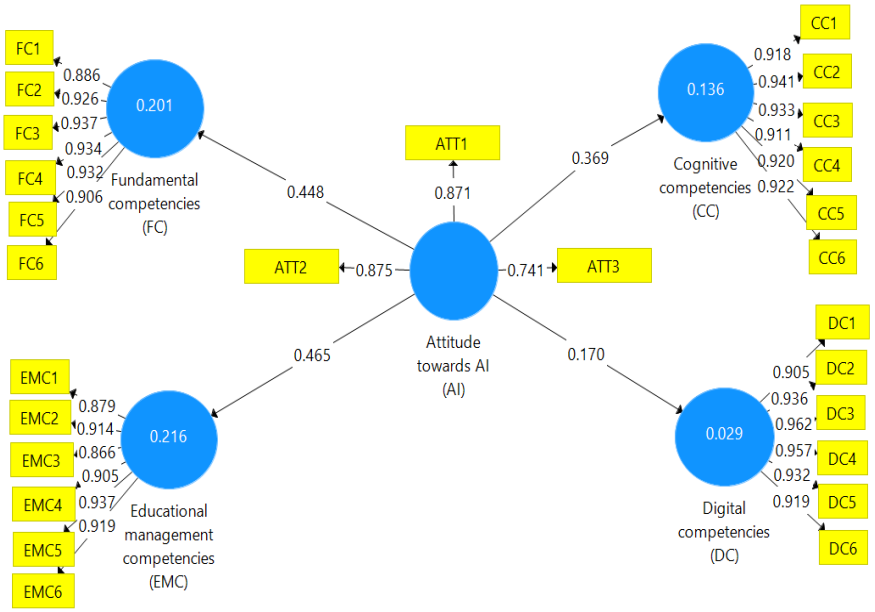


Figure no. 1. Model of the relationship between the positive attitude of teachers towards AI and their competencies (Structural model 1)

Thus, among the four constructs, the construct most influenced by the positive attitude of teachers toward AI is the construct related to educational management competencies (β = 0.465, R-squared = 0.216, p-value = 0.002), followed by fundamental competencies. (β = 0.448, R-squared = 0.201, p-value = 0.014), cognitive competencies (β = 0.369, R-squared = 0.136, p-value = 0.025), digital competencies (β = 0.170, R-squared = 0.029, p-value = 0.220). Since the R-squared in the case of digital competencies is not statistically significant (p-value > 0.10), we removed this construct from the model and we can argue that the H2 hypothesis is rejected. This outcome is corroborated by several other studies, such as those conducted by Ng et al. (2023), Vlasova et al. (2019) and Chounta et al. (2022). Despite their limited proficiency in AI-related domains, educators have demonstrated a willingness to endorse AI adoption. However, they have voiced concerns regarding the substantial effort required to acquire the necessary skills for proficiently using AI technologies and potential concerns about trust when employing AI tools. Therefore, it appears that teachers do not regard their digital competencies as adequate to address educational issues related to AI. The new proposed model is as follows:

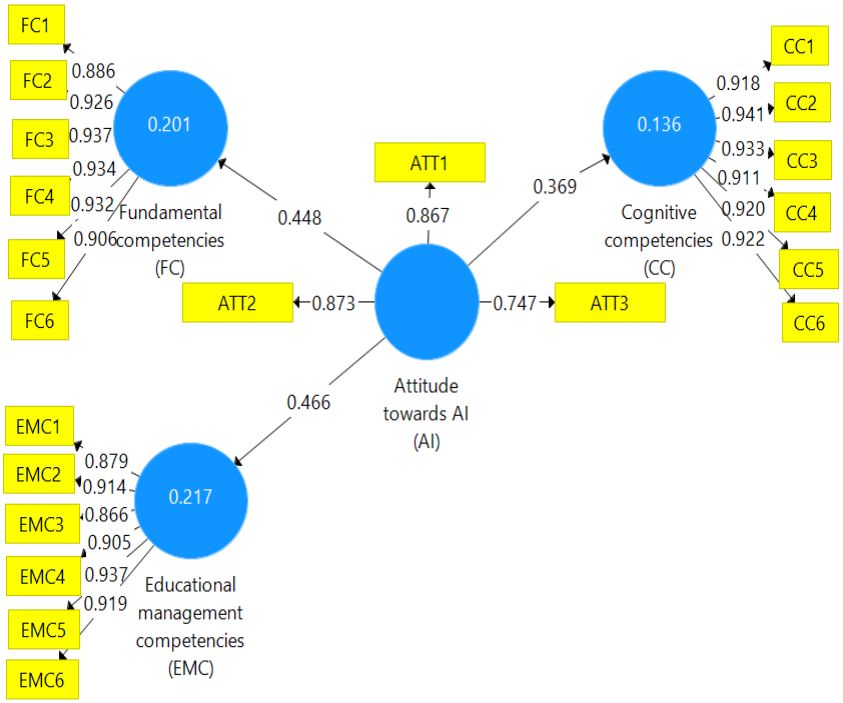


Figure no. 2. Model of the relationship between teachers' positive attitude towards AI and their cognitive, fundamental and educational management competencies (Structural model 2)

By using the standardised mean square root (SRMR), we evaluate the model fit. The SRMR value for the second estimated model is 0.045, less than 0.08, indicating a good model fit. Therefore, regarding the positive attitude towards AI of teachers, the more they agree with the statements that hold the AI development systems in high regard, nevertheless they recommend more the use of cognitive, fundamental and educational management

competencies in teaching development AI. Considering that all the indexes indicate a good fit of the model, we further tested the hypotheses H1, H3 and H4 with the help of PLS-SEM. We consider the procedure of bootstrapping (Table no. 3).

According to the results presented in Table no. 3, we can argue that the H1 hypothesis: ATT → *CC* (teachers' attitude towards AI influences cognitive competencies) is accepted (β = 0.369; p - value < 0.01). Regarding the hypothesis: *ATT → EMC* (teachers' attitude towards AI influences educational management competencies), because β = 0.466 and p - value < 0.01, we can confirm that the hypothesis H3 is accepted. Also, the H4 hypothesis: *ATT → FC* (teachers' attitude toward AI influences fundamental competencies) is accepted (β = 0.448; p - value < 0.01). Thus, we can conclude that the H1, H3 and H4 hypotheses are accepted.

Table no. 3. The influence of the positive attitude of teachers towards AI on the teachers' competencies (Path coefficients) – Model 2

Path	Path coefficient (β)	Standard deviation	T-statistics	p-value	Hypothesis
ATT → CC	0.369	0.087	4.253	0.000*	**H1 - accepted**
ATT → EMC	0.466	0.077	6.044	0.000*	**H3 - accepted**
ATT → FC	0.448	0.097	4.599	0.000*	**H4 - accepted**
* p-value < 0.01					

Source: own contribution

The presence of AI in both current and future education is undeniable. Educators are increasingly recognising AI's significance in education and its integral place within the classroom. This dynamic engenders a dichotomy between teachers and AI: some perceive AI positively, while others view it negatively. After testing the SEM model, we found a positive relationship between the attitude of teachers towards AI and cognitive, fundamental and educational management competencies. These findings align with the studies conducted by Vinichenko, Melnichuk and Karácsony (2020), Pedro et al. (2019), indicating that educators who maintain positive perspectives on AI within educational contexts are more predisposed to increase cognitive, digital, fundamental, and educational management competencies. Therefore, we can argue that positive proponents seek to cultivate the required competencies for AI integration, helping students use ethical and judicious AI to enhance educational outcomes.

4.2. Challenges and proposed measures regarding artificial intelligence

In the evolving context of education, the positive attitude of teachers toward AI plays an important role in shaping their competencies related to AI development. However, the results of the second structural model tested in the present research suggest that while this positive attitude undoubtedly influences their competencies, its impact could be less pronounced in competencies such as fundamental, cognitive, and educational management. Consequently, there is a critical need to investigate the challenges faced by educators to improve their attitudes toward strengthening these competencies. This aims to identify effective measures used to strengthen teacher attitudes, ultimately equipping them to engage with AI tools in

education more effectively. Therefore, we also looked at teachers' perspectives on the challenges facing education with the development of AI systems. Eight challenges were proposed, of which the respondents had to choose the first three most important challenges education faced with the development of AI systems from their point of view. The results are presented in Table no. 4.

Table no. 4. Challenges regarding artificial intelligence

Item	No. of respondents	Rank
Teacher professional development needs	87	1
Limited access to educational resources, technology and AI infrastructure	72	2
Updating the curriculum and educational policies for AI	63	3
Assessing the impact of AI on learning	52	4
Data privacy and security concerns	40	5
Ensuring equitable access to AI education	36	6
Balancing the use of AI in the teacher-student relationship	35	7
Preparing students for the AI-powered workforce	29	8

Source: own contribution

Based on the results, we can argue that most of the respondents consider that one of the most important challenges education faces with the development of AI systems is related to the need for professional development of teaching staff regarding artificial intelligence systems (87 respondents). A second important challenge regarding the relationship between education and AI is the limited access to educational resources, technology and AI infrastructure (72 respondents). Updates to AI curriculum and educational policies (63 respondents) represent the third important challenge in terms of the challenges education faces with the development of AI systems. Therefore, the professional development of educators requires the prioritisation of comprehensive and continuous professional development programmes tailored to equip educators with AI related competencies. This could include workshops, training courses and collaborations with AI experts to ensure that educators are adapted to using AI technologies for improved learning outcomes. These results are also supported by other research identified and presented in the theoretical background (Hussin, 2018; Vlasova et al., 2019; Owoc, Sawicka and Weichbroth, 2021; Zhao, Guo and Liu, 2021). There is also a need for policy makers to direct efforts toward reducing the digital divide by ensuring equitable access to educational resources, technology, and AI infrastructure. Initiatives to establish well-equipped artificial intelligence laboratories, provide access to educational platforms, and facilitate technological support in disadvantaged regions are essential. In terms of curriculum update, the integration of AI into curricula requires proactive updates to align educational content with evolutionary advances in AI. Policymakers should collaboratively develop curriculum guidelines and educational policies that integrate AI education across disciplines, encouraging comprehensive AI literacy among students.

Another aspect addressed in this research and which we consider important in the relationship between education and the development of AI systems is related to the measures that can manage the consequences of the integration of AI into society. Eight measures were proposed

from which the respondents were asked to select the first three most important measures. The results are presented in Table no. 5.

Table no. 5. Proposed measures regarding artificial intelligence

Item	No. of respondents	Rank
Continuous training and professional development of teachers	99	1
Creating AI educational resources	92	2
Quick updates to the curriculum	62	3
Personalised learning platforms	49	4
Government funding and support	38	5
Transparent communication	35	6
Digital inclusion initiatives	20	7
Curricular integration planning	19	8

Source: own contribution

Teachers believe that among the top 3 most important measures that can manage the consequences of AI integration in society are: Continuous training and professional development of teachers (99 respondents), Creation of educational AI resources (92 respondents) and Quick updates to the curriculum (62 respondents). We note that these measures are consistent with the challenges selected by the respondents regarding the development of AI systems. Therefore, the creation and dissemination of AI-focused educational resources should be a central policy focus. This involves developing comprehensive AI learning modules, digital libraries, and interactive platforms to facilitate educators' access to up-to-date AI content. In addition, policymakers must prioritise the establishment of comprehensive and targeted professional development programmes for educators. These initiatives should encompass AI-specific training, workshops, and collaborative partnerships with industry experts to empower educators with the requisite skills to effectively incorporate AI into the learning process.

Conclusions

The results presented demonstrate a positive correlation between teacher attitudes towards AI and the development of competencies across various categories. The most significant influence is observed in the field of educational management competencies, followed by fundamental and cognitive competencies. It follows that a positive attitude toward AI corresponds to an emphasis on cognitive, fundamental, and educational management competencies in educational practices. In the case of digital competencies, the results showed that the positive attitude towards AI does not influence these categories of competencies. According to the obtained results, we can argue that only the H1, H3 and H4 hypotheses are accepted. The influence of teachers' positive attitudes towards AI on cognitive, fundamental, and educational management competencies is statistically significant. This underscores the importance of fostering positive attitudes towards AI among educators for the development of various competencies.

The research identifies several challenges in integrating AI into education, such as the need for educators' professional development and equitable access to educational resources and technology. Policy makers should prioritise designing comprehensive professional

development programmes tailored to equip educators with AI-related competencies. Initiatives to bridge the digital divide and integrate AI education into curriculum are also essential policy implications. Teachers' perceptions of effective measures to manage AI's societal consequences underscore the importance of continuous training, creation of educational AI resources, and curriculum updates. These findings align with the identified challenges, underlining the need to develop and disseminate AI-focused educational resources and establish targeted professional development programmes for educators. The integration of AI in education requires a multifaceted approach encompassing legal frameworks, resource allocation, tailored educator training, and curricular adaptations. Such efforts are essential to harness AI's transformative potential and effectively prepare students for an increasingly AI-driven future. This comprehensive approach ensures that AI becomes an integral part of the educational landscape, allowing students to navigate the complexities of a technology-rich world while preserving the invaluable human touch in the learning process.

The original contribution of the research consists of a unified approach of the relationship between the positive attitudes of teachers towards artificial intelligence and a series of skills (cognitive, fundamental, and educational management), which addresses the fact that a large part of the literature addresses only one category of competencies in relation to teachers' attitude towards artificial intelligence and ignores the unity of competencies.

This research is not without challenges and limitations. The first limitation of this research is the relatively small number of survey respondents. Other limitations of the research refer to the way in which the items referring to the positive attitude of teaching staff with regard to AI and the relatively small number of items for this construct were selected. Additionally, the scope of the study is limited to a single region and generalisation of the findings to other regions may require further investigation. In this research, we focus on the positive attitude of teachers towards AI, and in future research, we propose to address a critical analysis from teachers towards AI, including their reservations towards the expansion of AI in education.

Future research could address the limitations of this study by expanding the sample size and improving the measurement of teaching staff attitudes and competencies on AI. Additionally, further investigations could examine the specific content and delivery methods of professional development programmes aimed at equipping educators with AI related competencies and knowledge.

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