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Confronting the Impact and Challenges of the AI Era: Teachers' Creative Use of Digital Tools to Enhance Digital Teaching Competence

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Abstract: Teachers' digital teaching competency is key to navigating the educational transformation in the AI era. This study explores the factors influencing teachers' digital teaching competence by constructing multiple linear regression equations. The findings show that human-computer collaboration ability can significantly and positively explain 86.2% of the changes in digital teaching competence, making it the primary factor influencing digital teaching competence. In addition, this study considered the effects of teachers' gender, teaching experience, professional seniority, and pedagogical content knowledge and critical thinking on digital teaching competence. Combined with the results of the study, it is suggested that teachers should emphasize improving digital literacy and human-computer collaboration ability in the AI era, innovatively use digital tools during the teaching process, and deepen the understanding of pedagogical content knowledge and the cultivation of critical thinking, in order to better navigate the opportunities and challenges of the AI era.

Keywords: AI Era, Digital Tools, Digital Teaching Competence, multiple regression linear equations

1. Introduction

With the development of digital technology and the deep integration of artificial intelligence into education and teaching, we have entered the AI era of education (Ahrofi, 2025). In this context, the sustainable development of educational digitization and the transformation of education in the AI era drive teachers to master more solid digital teaching competence to address the impact and challenges of the AI era on the role of teachers (Rahmadi et al., 2021). Research has indicated that the integration of technology in teaching is a key factor in improving learning quality (McKnight et al., 2016). This requires teachers not only to possess a certain level of digital technology knowledge and skills but also to have the ability to seamlessly integrate technology into the classroom, employing innovative teaching strategies to achieve efficient human-computer collaboration in the classroom (Yang, 2024). Researchers have noted that there is a certain correlation between teachers' digital teaching competences and their ability to collaborate with digital technologies such as artificial intelligence (Kim, 2024). This means that when teachers can better collaborate with technologies like artificial intelligence, their digital teaching competences will also improve accordingly. In addition to focusing on teachers' human-computer collaboration capabilities, teachers' pedagogical content knowledge is equally important. According to the TPACK theory, when teachers use technology for teaching, their teaching effectiveness is also significantly influenced by their pedagogical content knowledge (Schmid et al., 2024). The use of digital technologies like AI can greatly facilitate teaching, but teachers who blindly use digital technologies in teaching may have negative teaching effects (Zhang et al., 2024). Therefore, critical thinking is a key ability for both teachers and students to adapt to digital transformation (Butler, 2024). The UNESCO-published “AI Competency Framework for Teachers” also

emphasizes that teachers should be able to critically evaluate the application of AI technology in teaching (Cukurova & Miao, 2024). Additionally, from the perspective of teachers' instructional skills, research by Fu Zhuqin and Cai Li (2022) indicates a significant positive correlation between teachers' critical thinking and effective classroom instruction, suggesting that teachers' instructional capabilities are influenced by their critical thinking skills. Other studies also indicate that critical thinking helps teachers flexibly address complex and dynamic teaching situations and resolve various new challenges encountered (Zhang Yin et al., 2018). Thus, teachers' critical thinking may also have a certain influence on their digital teaching capabilities.

Although the aforementioned studies have conducted a comprehensive and in-depth analysis of teachers' digital teaching competences from a theoretical perspective, there is a lack of corresponding empirical research to further validate the validity and applicability of these theoretical perspectives. To address this research gap, this study aims to construct a multiple linear regression model to explore the impact of teachers' human-computer collaboration abilities on their digital teaching competences, while also considering the roles of pedagogical content knowledge and critical thinking as two important factors.

2. Method

2.1 Participants

This study randomly selected primary and secondary school teachers in a certain district of S City, China, as the survey subjects. A total of 165 questionnaires were collected, of which 150 were valid, resulting in a validity rate of 90.91%. This sample is dominated by female teachers, a total of 120, accounting for 80%. In this sample, there were 27 (18.0%) teachers with less than 5 years of teaching experience, 31 (20.7%) with 6-10 years of teaching experience, 27 (18.0%) with 11-15 years of teaching experience, 15 (10.0%) with 16-20 years of teaching experience, and 50 (33.3%) with more than 20 years of teaching experience. In addition, in terms of the distribution of professional seniority, 49 (32.7%) teachers were elementary school level 1 teachers, 33 (22.0%) were elementary school level 2 teachers, 9 (6.0%) were senior elementary school teachers, 32 (21.3%) were secondary school level 1 teachers, 4 (2.7%) were secondary school level 2 teachers, 13 (8.7%) were senior secondary school teachers, and 10 (6.7%) had no titles.

2.2 Research Tools

In terms of scale design, the reference indicators for teachers' digital teaching competence (DTC), human-computer collaboration (HC), and critical thinking (CT) were borrowed from Zheng Xudong's (2019) digital competence model for primary and middle school teachers. The DTC dimension includes five items, with an example question being, “I can select appropriate digital resources for instructional design based on the development of students' core competencies”; the HCC dimension includes five items, with an example question being, “I can proficiently use AI tools to assist me in instructional activities”; and the CT dimension includes five items, with an example question being, “Before applying digital technology in instruction, I will thoroughly assess its compatibility with instructional activities.” The reference indicators for teachers' pedagogical content knowledge (PCK) primarily draw from the PCK-related items in the TPACK scale designed by Schmidt (2009) et al., totaling 5 items. An example question is: “I can select effective teaching methods to enhance students' core competencies”. The questionnaire was in the form of a five-point Likert scale, with scores from 1 to 5 representing “strongly agree”, “agree”, “generally”, “Disagree” and “Strongly Disagree”. After the samples were collected, the questionnaire was analyzed for reliability in this study, and its Cronbach's alpha coefficients for each dimension were greater than 0.8, with good reliability(Thanasegaran, 2009). Then, the questionnaire items were subjected to exploratory factor analysis using SPSS 26.0, and the resulting KMO statistic was 0.949, and the *p*-value of the Bartlett's test of sphericity was less than 0.05, which indicated good validity.

2.3 Data analysis

In this study, the correlation analysis was conducted through SPSS 26.0 by first using Pearson's coefficient to test whether there is a significant correlation between different genders (Gender), years of teaching experience (TE), professional seniority (PS), and teachers' human-computer collaborative ability, pedagogical content knowledge, and teachers' critical thinking on their ability to teach digitally at the level of 0.05, and then constructed a multiple linear regression model for analysis.

3. Results

3.1 Correlation analysis

From the results of the correlation analysis, the teachers' digital teaching competence in this study showed a significant negative correlation with the teachers' teaching age and title, indicating that the lower the teachers' teaching age and teaching title, the higher the teachers' digital teaching competence. There was a significant positive correlation between teachers' digital teaching competence and teachers' human-computer collaborative ability, subject-matter pedagogy knowledge and critical thinking, indicating that the higher the human-computer collaborative ability, subject-matter pedagogy knowledge, and critical thinking, the higher the teachers' digital teaching competence. In addition, there was no correlation between teachers' titles and their pedagogical content knowledge and critical thinking. There was no correlation between teachers' gender and all variables.

Table 1. Analysis of correlation results

	DTC	HCC	PCK	CT	TE	PS	Gender
DTC	1.000	.929**	0.808**	0.848**	-0.267**	-0.200*	-0.107
HCC	0.929**	1.000	0.720**	0.797**	-0.309**	-0.209*	-0.060
PCK	0.808**	0.720**	1.000	0.692**	-0.139	-0.150	-0.133
CT	0.848**	0.797**	0.692**	1.000	-.0229**	-0.122	-0.108
TE	-.267**	-.309**	-0.139	-.229**	1.000	0.151	-0.088
PS	-.200*	-.209*	-0.150	-0.122	0.151	1.000	-0.082
Gender	-0.107	-0.060	-0.133	-0.108	-0.088	-0.082	1.000

**p<0.01, *p<0.05

3.2 Multiple linear regression analysis

The results of the above analysis show that human-computer collaborative competence, subject pedagogy knowledge and critical thinking are all significantly related to teachers' digital teaching competence. In this study, teachers' digital teaching competence was taken as the dependent variable, human-computer collaborative competence was taken as the independent variable, and considering that teachers' pedagogical content knowledge and critical thinking as well as teachers' years of teaching experience and professional title may have some interfering effects on the model, they were also taken as the control variables, and the multivariate linear regression model was constructed as follows:

$$DTC = a + b_1HCC + b_2PCK + b_3CT + b_4TE + b_5PS$$

Where a is the constant, b_1, b_2, b_3, b_4, b_5 are the regression coefficients. After testing, the residual sequence of the regression model passed the autocorrelation and normality tests: the Durbin-Watson statistic was 2.083, indicating that the residuals did not exhibit significant first-order autocorrelation; the Shapiro-Wilk normality test confirmed that the residuals were normally distributed (p > 0.05). Additionally, multicollinearity diagnostics show that the variance inflation factor (VIF) for all variables is less than 5, indicating that the model does not have serious multicollinearity issues. The regression results are shown in Table 2.

Table 2. *Analysis of MLR results*

Variables	Model 1	Model 2	Model 3
（constant）	0.564**	-0.048	-0.015
HCC	0.848**	0.534**	0.529**
PCK		0.207**	0.209**
CT		0.257**	0.257**
TE			-0.001
PS			-0.006
R2	0.862	0.919	0.919
△R2	0.861	0.917	0.917
F	927.163**	549.472**	326.321**

**p<0.01, *p<0.05

Based on the regression results, we found that all three regression models passed the test at the 0.01 significance level. In Model 1, which contains only the independent variable human-computer collaborative ability, the value of R^2 is 0.862, indicating that teachers' human-computer collaborative ability explains 86.2% of the variation in digital teaching competence and is the main factor influencing digital teaching competence. With the addition of teachers' pedagogical content knowledge and critical thinking, the model overall explains 91.9% of teachers' digital teaching competence, indicating that teachers' human-computer collaborative ability, pedagogical content knowledge, and critical thinking are able to cover most of the reasons for the changes in teachers' digital teaching competence. However, we found that after introducing teachers' pedagogical content knowledge and critical thinking, the coefficient of explanation for human-computer collaboration ability decreased from 84.8% to 53.4%. Combined with the results of the correlation analysis, this indicates that teachers' pedagogical content knowledge and critical thinking explain part of the impact of human-computer collaboration ability on digital teaching competence, thereby correcting our previous overestimation of the explanatory power of human-computer collaboration ability. This also indicates that teachers' pedagogical content knowledge and critical thinking skills will also affect their human-computer collaboration abilities. In Model 3, we further introduced teachers' teaching experience and professional title as control variables based on the results of the correlation analysis, but the overall explanatory degree of the model did not change significantly, and there was no significant linear relationship between these two variables on teachers' digital teaching competence. Combined with the correlation results, teaching experience and professional title may explain a small portion of the effect of the above three variables on the dependent variable, but this effect is not significant.

4. Discussions and implication

Combining the results of the above data analysis, we conclude that teachers' human-computer collaboration ability is the main factor affecting their digital teaching ability, and that when teachers' human-computer collaboration ability is stronger, their pedagogical content knowledge is richer, and their critical thinking is stronger, their digital teaching ability is correspondingly higher. This finding suggests that if we want to improve teachers' digital teaching ability, we should start from strengthening teachers' human-computer collaboration ability and provide them with targeted training, and at the same time pay attention to strengthening teachers' pedagogical content knowledge and critical thinking.

In addition, we found that although teachers' teaching experience and professional title have some correlation on teachers' digital teaching ability, they do not have a significant linear relationship on the dependent variable, teachers' digital teaching ability, in the multiple linear regression model. This indicates that although teachers' years of teaching experience and professional title have some effect on their digital teaching competence, this effect is not significant. It proves that teachers' digital teaching competence is mainly related to their own

competence, knowledge accumulation and personal attributes. Further, combining the results of the correlation analysis, we find that teachers' knowledge accumulation is not directly related to their traditional teacher characteristic factors such as gender, teaching experience and professional title, which breaks certain stereotypes or assumptions that may have existed in the past, and emphasizes the plurality and independence of teachers' knowledge accumulation. We also found a significant negative correlation between teachers' human-computer collaboration skills and critical thinking and teaching experience, suggesting that younger teachers may be more active and adept at using digital technology. This may be due to the fact that young teachers grew up in an era of rapid development of digital technology, and they are more likely to accept and master new technologies, thus showing an advantage in human-computer collaborative skills. In addition, younger teachers may also be more accustomed to questioning and reflecting, thus showing greater competence in critical thinking as well. However, this advantage requires a more dialectical perspective: on the one hand, technical proficiency is indeed often associated with youth, but truly effective “human-computer collaboration” lies in the educational wisdom of deeply integrating technology with pedagogy, which often requires accumulated experience; on the other hand, critical thinking is not merely about questioning habits but also involves a profound understanding of the educational value, potential risks, and ethical implications of technology application, which may precisely be the unique perspective that experienced teachers can offer based on their rich practical experience. Therefore, the vitality of young teachers and the experience of older teachers are not mutually exclusive; intergenerational collaboration and complementarity are essential to fully unlock the educational value of human-machine collaboration.

Therefore, we make the following recommendations: in order to enhance teachers' digital teaching ability in the digital era, in addition to focusing on their teaching ability, teachers' personal development training should be emphasized. The technical advantages and innovative thinking of young teachers should be fully utilized, and they should be encouraged to actively use digital technology in their teaching practice, promote the innovation of teaching methods, and explore the teaching mode of human-computer collaboration. Meanwhile, for senior teachers, it is also necessary to continuously enhance their abilities in digital technology and critical thinking through continuous professional training and learning to meet the needs of educational development. Teachers' knowledge accumulation is a complex and multifaceted process that may be affected by a variety of factors, including individual learning habits, teaching environment, and professional development opportunities. This finding has important implications for education policy makers, school administrators, and teachers themselves, suggesting that we should pay more attention to teachers' individual differences and professional development needs, and provide them with diversified learning and development opportunities to promote their knowledge accumulation and professional growth.

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