Influences of Artificial Intelligence in Education on Teaching Effectiveness

The Mediating Effect of Teachers' Perceptions of Educational Technology

Hualiang Lin[✉]
Zhejiang Tourism College, Hangzhou, China
lhl@tourzj.edu.cn

Abstract—The continuous development and application of artificial intelligence (AI) technology greatly support education reform and profoundly influence the learning styles of learners. Artificial intelligence in education (AIED) can help teachers recognize teaching tasks explicitly and teach content accurately. Moreover, AIED can help students change the traditional learning styles according to their differences, thereby realizing intelligent teaching and meeting the learning needs of students. A good teachers' perception of educational technology (ET) is beneficial for using AI technology to positively assist all teaching links, which in turn improves teaching effectiveness. In this study, five hypotheses concerning the influences of AIED on teaching effectiveness were verified. The teachers' perception of ET was introduced as a mediating variable, and the mediating effect of AIED on the improvement of teaching effectiveness was analyzed. The influences of AI using the period of learners on teaching effectiveness were estimated. Results showed that the overall Cronbach α and Kaiser–Meyer–Olkin of the designed questionnaire were 0.907 and 0.878, respectively. Moreover, the χ^2 of Bartlett's test of sphericity reached the 0.01 significance level, indicating the considerable good reliability and validity of the questionnaire. All four aspects, namely, AI-assisted teaching, exercise, exam, and assessment, had significantly positive influences on teaching effectiveness. The teachers' perceptions of ET played a partial mediating effect for AIED on the improvement of teaching effectiveness. Samples with different AI-using periods had significant influences on teaching ($p < 0.01$). Research conclusions can provide important references to teachers for making scientific use of AIED and propose more accurate teaching strategies according to the learning states of learners.

Keywords—artificial intelligence (AI), assisted teaching, teaching effect, teachers' perceptions of ET, mediating effect

1   Introduction

The comprehensive integration of artificial intelligence (AI) into education has proposed more requirements for teaching reform. With the gradual deep development and increasing application scenes of AI technology, many scholars viewed AI technology as the core means that influences reforms of the teaching method. AI has been extensively used in schools of different levels and categories. Teachers increasingly began to apply AI technology-assisted teaching. As AI technology becomes increasingly mature, artificial intelligence in education (AIED) will realize man–machine interactive systems and real communication functions, which can better promote the improvement of teaching quality, facilitate optimization of learning philosophy and perfection of learning style and encourage teachers to accept AI technology more positively. In particular, AI can help learners change the traditional learning style depending on teachers' teaching and use a "self-study"-oriented learning method. In addition, AI technology helps teachers understand teaching tasks more clearly, teach content accurately, choose teaching keys, and make a scientific assessment of learners' study life. Hence, AI technology plays an important role in promoting the development of learners.

Teachers' perceptions of educational technology (ET) are based on their teaching experiences accumulated in the long-term teaching process. Given a higher level of teachers' perceptions of ET, teachers are more likely to adopt different teaching methods and make some teaching decisions according to the needs and practical situations of learners to guide teaching practices. Assisted by AIED, teachers with high technological recognition can maintain closer communications, interactions, and cooperation with colleagues, and they are willing to discuss and negotiate with leaders about teaching objectives. Teachers' perceptions of ET are beneficial for them to update and expand comprehensive cognitions of professional knowledge, strengthen full communication and interaction with colleagues, promote their professional development, and improve classroom teaching quality.

2   Theoretical bases and research hypotheses

2.1   Theoretical bases

In the current age of the developed network, Goldie, J. G. S [1] believed that in the age of the Internet, knowledge source is attacking the brains of learners in an unprecedented way, and knowledge can exist in carriers rather than inside human, thereby forming knowledge "nodes". Learning is to establish connections among these nodes. The core opinion of connectivism provides a theoretical basis for this study because AIED technology can realize problem-solving and knowledge characterization. Moreover, connectivism can be iterated and optimized continuously by updating the knowledge base, thereby further improving its applicability and practicability in assisted teaching. Connectivism can construct a perception data model for data and experiences produced in relevant teaching links by using AI technology, which can help optimize the teaching activities of teachers. Through data analysis and processing technology, learners can understand learning contents more intuitively and clearly, thereby improving learning efficiency.

2.2 Research hypotheses

The most common AI technologies in the teaching assistance field include knowledge mapping and data science. AIED provides information supports to review knowledge points and master the learning schedule of learners during the preparation of lessons and textbook compilation. Teachers can construct models of learners' features, hobbies, learning routes, and behavioral habits through a clustering analysis algorithm, thereby providing personalized learning methods to different types of learners. In view of education scenes, the mainstream scenes can be divided into five aspects, namely, teaching, exercise, exam, assessment, and management.

Cumming [2] believed that with the fast iteration and maturity, the intelligent technologies represented by AI had been extensively studied and applied in multiple fields. In particular, the application of AI technologies in education teaching has promoted the improvement of teaching effectiveness significantly. Knox [3] pointed out that AI technology can simulate human thinking structure and the ability to solve problems and exhibit and process information. Yang [4] analyzed manifestations of teaching effectiveness of professional art courses in the background of AI and discussed relevant influencing factors of teaching effectiveness. The results demonstrated that university teachers should introduce AI to improve teaching effectiveness of professional courses more innovatively. Bin and Mandal [5] reported that the rapid development of AI technology makes it possible to give automatic scoring for English writing and proposed an implementation scheme for college English teaching systems with the assistance of AI technology. According to research results, AI technology improved some functions of the English teaching system and realized the humanization of the system. Ocaña-Fernándezet et al. [6] revealed that AI could enhance education at all levels and bring unprecedented quality improvement as it can meet students' requirements and provide them with accurate, personalized learning. Huang [7] analyzed the relationship between AI course and key ability training of students through a questionnaire survey. The results showed that the AI course was beneficial in training six key sub-abilities of students. Hence, the first hypothesis (H1) was proposed in this study.

H1: AI-assisted teaching can evidently improve teaching effectiveness.

Ahmad et al. [8] discussed the role of AI applications in education and found that social communication robots, intelligent learning, and intelligent teaching system played an important role in improving the repeated skill practices of learners. Van der Niet and Bleakley [9] deemed that AI technology was expected to change the teaching mode of medical education. In particular, the extensive applications of AI technologies in medical practice allowed to transfer of clinical medical work to the fuzzy scenes of "technological enhancement" and provided strong virtual scenes for medical practice. Paranjape et al. [10] believed that medical practice required AI support and medical equipment supported by AI improved clinical decision-making by using more data, thereby facilitating the demands of medical students for repeated practices in the man–machine interaction. Du Boulay [11] demonstrated that the combination of AI technology and educational teaching helped teachers better understand the essence of

learning and teaching and helped learners obtain new skills or understand new concepts. Hence, the second hypothesis (H2) is proposed as follows:

H2: AI-assisted exercise can evidently improve teaching effectiveness.

Wang and Zhang [12] reported that the traditional written examination could not meet the exam requirements of students anymore. He developed an exam system based on AI technology which had good cognitive diagnosis ability and achieved high efficiency and accuracy in question selection, enabling to improve performances in students' ability assessment. Park et al. [13] believed that AI technology could be applied to the skill assessment of medical students who should master skills related to medical AI. Zhuravlova et al. [14] found that AI-assisted exams could be provided to students, which improved education efficiency and the quality of pupils. Ebadi and Amini [15] used AI technology as assistance in English tests, which could strengthen learners' motivation, enthusiasm, and confidence in English learning. Hence, the third hypothesis (H3) is proposed as follows.

H3: AI-assisted exams can evidently improve teaching effectiveness.

Qu et al. [16] believed that the combination of AI and education would bring a new educational development mode and promote better education. AI could provide personalized teaching programs and meet the needs of students' intelligent assessment. Chassignol et al. [17] also believed that the organic integration of AI technology and teaching could create more intelligent and personalized teaching environments and provide a good atmosphere for relevant teaching activities. Moreover, AI-assisted education could describe the personalized characteristics of learners accurately, make a scientific evaluation of teaching activities and process design, and guarantee the implementation of personalized teaching. Kumar [18] believed that the AI application in the new education paradigm and its changing roles to create a personalized teaching environment are conducive to realizing complete learning and assessment processes. Hence, the fourth hypothesis (H4) is proposed as follows:

H4: AI-assisted assessment can evidently improve teaching effectiveness.

Wang and Cheng [19] found that AIED shall take differential strategy into account during specific applications to cope with the needs of learners and improve teaching management specifically. Popenici and Kerr [20] discussed the current situation of AI applications in higher education and believed that AI would influence more significantly the future properties of higher education globally, particularly in teaching, learning, students' support, and management. Barakina et al. [21] believed that AI technology promotes the digitalization of education and the introduction of new technologies provides new opportunities for improvement of the education management process. Lee [22] carried out AI education and observed changes in students' attitudes toward AI technology. He found that AI technology could increase learners' need for AI-assisted education and that teachers would be more positive in improving teaching management. Hence, the fifth hypothesis (H5) is put forward as follows:

H5: AI-assisted management can evidently improve teaching effectiveness.

Moreover, the research results of Wood et al. [23] revealed that teachers' perceptions of ET could spread information among teachers and promote the learning effect of teachers. In particular, spreading AI information brings teachers more technological knowledge and improves teachers' perceptions of ET, thereby increasing the application rate of technologies. John [24] implemented an extensive interview with 37 respondents from six fields of disciplines. The author concluded that technological information is accumulated as teachers increasingly began to use advanced teaching technologies in teaching activities, which further increased teachers' perceptions of ET. Ma et al. [25] collected 84 completed surveys from students and teachers in a university in Sweden and found that more teachers know AIED because of the increasing diffusion efficiency. According to research results, Assaf [26] found that online discussion forums could provide students and teachers with professional and individual support. In addition, teachers could master technological operation methods better through communication with colleagues, which was conducive to developing the technological effect. Young teachers were particularly more willing to use technology. Therefore, the sixth hypothesis (H6) is put forward as follows:

H6: Teachers' perceptions of ET provide a mediating effect for AIED to promote the teaching effectiveness.

3 Research design

3.1 Questionnaire design

A questionnaire was designed in this study based on the literature review. The questionnaire covered four aspects: (1) measurement of AIED. In this study, research conclusions of Pantic et al. [27], Martınez-Miranda and Aldea [28] were introduced. AIED was mainly reflected in five aspects of teaching, namely, teaching, exercise, exam, assessment, and management. A total of 4, 5, 4, 4 and 4 questions were designed for these five aspects, respectively. (2) Measurement of teaching effectiveness. Research conclusions of Voogt et al. [29] were used, and 6 questions were designed for measurement. (3) Measurement of the mediating variable. Teachers' perceptions of ET refer to subjective understanding and practice tendency of teachers to AI-assisted teaching. Based on the scale of teachers' perceptions of ET designed by Davis [30] and Venkatesh [31], 6 questions were designed according to ability and value perceptions. (4) Descriptive statistics of respondents. This part mainly included gender, grade, major, and use period of AI. All questions were measured by the seven-point Likert scale.

3.2 Respondents

Zhejiang Province, China, has been an advanced province in higher education. Zhejiang Province even issued the Evaluation Index System for Intelligent Campus in Zhejiang Province to guide the modernized development of education, thereby realizing

the reform of teaching modes in higher education and education digital transformation in universities. Based on the research team survey, a questionnaire survey was carried out to undergraduates from the School of Economics and Management at Zhejiang University of Technology, Hangzhou Electronic Science and Technology University, Zhejiang University of Technology, Zhejiang Gongshang University, Zhejiang A & F University, Zhejiang University of Finance and Economics, Zhejiang University of Science and Technology, Zhejiang University City College, and Zhejiang Shuren College. The questionnaire was implemented online by designing a QR code for students from the School of Economics and Management of the above nine universities, and 368 questionnaires were collected. After invalid questionnaires were eliminated, 290 valid ones were retained, showing an effective recovery rate of 78.80%. Table 1 presents the descriptive statistical results of respondents.

Table 1. Descriptive statistical results of respondents

Name	Option	Frequency	Percentage (%)
Gender	Male	171	58.97
	Female	119	41.03
Grade	Freshman	36	12.41
	Sophomore	98	33.79
	Junior	103	35.52
	Senior	53	18.28
Major	E-commerce	38	13.10
	Logistics management	74	25.52
	Marketing	25	8.62
	Business management	41	14.14
	Accounting	39	13.45
	Human resource management	73	25.17
Using period of AI	No contact	7	2.41
	<0.5 years	3	1.03
	0.5–1 year	87	30.00
	1–2 years	109	37.59
	2–3 years	74	25.52
	>3 years	10	3.45

4 Results analysis

4.1 Reliability and validity tests

Reliability mainly refers to whether the test is credible and whether the data obtained is reliable. Validity is the extent to which a test or measuring instrument can truly measure what is being measured.

Table 2. Reliability test results

Variable Type	Variable Name	Number of Questions Measured	Cronbach's α	Cronbach's α
Independent variables	Teaching	4	0.899	
	Exercise	5	0.939	
	Exam	4	0.927	
	Assessment	4	0.910	0.907
	Management	4	0.932	
Dependent variable	Teaching effectiveness	6	0.778	
Mediating variable	Teachers' perceptions of ET	6	0.790	

Table 2 shows that after calculation, the overall Cronbach's α of the questionnaire was 0.907 (>0.9), indicating the high overall reliability of this study. Moreover, the reliability coefficients of all dimensions were higher than 0.7, indicating the good internal consistency of the questionnaire.

Table 3. KMO and Bartlett's test

KMO		0.878
Bartlett sphericity test	Approximate chi-square	7534.25
	Degree of freedom	528
	p	0.00

Table 3 presents the validity test results of the questionnaire. The Kaiser–Meyer–Olkin (KMO) test was 0.878, and χ^2 of Bartlett's test of sphericity reached the 0.01 significance level. In other words, common factors exist among relevant matrixes of questions, indicating the good validity of the questionnaire.

4.2 Regression analysis

Table 4. Linear regression results

Variables	Standardization Coefficient	T	P	VIF	F
Constant	–	13.102	0.000**	–	
Teaching	0.301	6.193	0.000**	1.106	
Exercise	0.223	3.119	0.002**	2.390	F(5,284) = 36.546, p = 0.000
Exam	0.325	4.552	0.000**	2.376	
Assessment	0.154	2.960	0.003**	1.268	
Management	0.029	0.564	0.573	1.255	

Notes: *p < 0.10 , **p < 0.05 , ***p < 0.01.

Table 4 shows the F test results of the linear regression model. Evidently, the model passed the F-test (F = 36.546, p = 0.000 < 0.05).

(1) H1 was confirmed. Generally, this conclusion is consistent with the conclusions of most studies. The reason is mainly that AI-assisted teaching allows teachers to use more personalized teaching plans. In particular, computer vision, natural language processing, and data mining in AI technology provide teachers with technological possibilities. Personalized teaching plans can be produced for teachers according to the class condition or individual situations, including teaching plans, classroom exercises, homework assignments, and others. In addition, the latest technologies, such as speech processing, computer vision, data mining, and VR technology, allow more new teachers to have trial teaching training and provide teachers with virtual classroom scenes for pre-practice teaching content.

(2) H2 was confirmed. AI technology can help teachers provide more accurate teaching services to review the activities of learners. Teachers can offer more scientific practice suggestions to each learner according to their mastered knowledge and help them to master key and difficult knowledge points in the course. Assisted by natural language processing and data mining of AI, teachers can realize batched intelligent homework checking more effectively. In particular, they can help teachers in checking objective questions more effectively. The natural language processing of AI can help teachers to answer personalized questions from learners more effectively. With respect to questions of learners, the AI assistant imitates the behavioral mode of humans to make intelligent communication with learners and give them personalized answers, thus relieving teachers' pressure in some simple repeated learning processes.

(3) H3 was supported. Major reasons are introduced as follows. Teachers can realize the personalized construction of test papers through data mining and text analysis of AI. By analyzing and combining structuralized data in the question library, teachers can provide exams to different classes according to study conditions. In addition, AI technology helps teachers in intelligent paper inspection, including checking and scoring objective or subjective questions. It also can provide thoughtful analysis of students' exam performances, make a diagnosis of reasons for mistakes, summarize exam results of the class, produce exam performance analysis reports, form a set of reasons for mistakes, and assist teachers in targeted teaching. In the invigilation, computer vision technology of AI can fully analyze the actions of students in the video of the examination room, provide all-around invigilation, decrease workloads and pressure of invigilation teachers, and improve invigilation quality.

(4) H4 was supported. Major reasons are introduced as follows. Assisted by AI technology, teachers can assess the vocational interest of learners more effectively. Based on differential strengths and personal characteristics of learners, AI technology can assess vocational interests and produce professional recommendations intelligently, which is conducive to a high agreement between their professional career plan and actual development. Additionally, AI technology can assess classroom teaching quality effectively; build a full-coverage classroom teaching quality assessment system that can provide fast feedback and comprehensive, objective, and scientific classroom assessment reports; and help the management department of universities in effective monitoring over teaching behaviors of teachers.

(5) H5 was rejected. AI technology can assist in class management; recognize actions, facial expressions, and language of students in class and teacher–student interaction; analyze classroom learning effect of learners; and produce statistical and analysis reports.

However, H5 was not supported for the following possible reasons. The daily activities of learners are closely related to teaching activities, but they failed to obtain a profound understanding of AI-assisted university management. Nevertheless, teaching effectiveness is a comprehensive index, and teaching management is important content. This case also reminds teaching management departments of universities to not only increase the interpretation of professional knowledge to learners but also help learners to deepen their understanding of various management equipment, management system, and management staffs in universities. Thus, they can be more accustomed to various AI-assisted teaching management equipment and improve overall teaching effectiveness.

4.3 Mediating effect

Table 5. Results of mediating effect

Variable	Teaching Effectiveness	Teachers' Perceptions of ET	Teaching Effectiveness
Constant	3.147** (13.310)	3.011** (8.163)	2.550** (10.201)
AIED	0.403** (7.958)	0.347** (4.395)	0.334** (6.705)
Teachers' perceptions of ET	–	–	0.198** (5.517)
F-value	F(1,288) = 63.328, p = 0.000	F(1,288) = 19.319, p = 0.000	F(2,287) = 50.119, p = 0.000

Notes: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 5 shows that H6 was true. This result was relatively consistent with the research conclusions of Dori and Belcher [32], Lee and Tsai [33], and Bryndin [34]. Major reasons are introduced as follows. The primary task in improving teaching effectiveness is to improve teachers' perceptions of ET comprehensively. The expectation that universities create a cultural environment for intelligence flowing and teachers use more modernized teaching technologies becomes increasingly evident, and the practice achieves more significant outcomes. The reason is that AI-assisted teaching is the unity of progress and tortuosity. Given the more ideal organizational supports or classroom culture, teachers can perceive the actual necessity of AI-assisted teaching better and thereby are easier to produce motivation and confidence in practices, enabling to achieve better teaching effectiveness. Teachers who have more sufficient perceptions of ET are more apt to the innovative design of teaching contents and activity flows, and they become more positive to step out of their comfort zone in traditional teaching. In this process, teachers show higher value perception and practice confidence in AI-assisted education. They expect disruptive innovation in teaching practices through continuous inputs of time and effort. Hence, we shall fully motivate positive psychology and efficacy expectation of teacher's ability perception and encourage teachers to carry out AI-assisted teaching, aiming to improve AI-assisted teaching effectiveness gradually. By using AI technology, teachers can help learners at different cognition levels to choose reasonable course resources and intelligent tools. This technology is also the key to AI-assisted teaching and scientific implementation of educational practices.

4.4 Difference analysis

Table 6. Variance test results

Analysis Term	Using Period of AI	Mean	Standard Deviation	F	P
Teaching effectiveness	No contact	7	4.86	5.276	0.000**
	<0.5 years	3	6.67		
	0.5–1 year	87	5.37		
	1–2 years	109	5.51		
	2–3 years	74	5.12		
	>3 years	10	3.8		
	Total	290	5.31		

Table 6 shows that samples with different AI-using periods all have significant influences on teaching effectiveness (p < 0.01), indicating that teaching effectiveness varies with the AI-using period. The main reason is that AI-assisted teaching is a reform of teaching mode, but learners who are the subjects of learning activities have to be familiar with AI technology to some extent. Additionally, learners who use AI for 0.5–2 years showed the best teaching effectiveness, indicating that learners must have a full understanding of AI technology. When teachers use AI-assisted teaching, learners have to analyze the learning analysis results provided by the platform according to their learning state, adopt corresponding measures, make self-reflection, and adjust their learning state to realize high-efficiency independent studies. According to learning feedback from AI technology, learners can stimulate learning enthusiasm by optimizing learning methods and realizing adaptive teaching. This case also reminds university teachers to pay close attention to ways and methods for learners to integrate leading technologies (e.g., AI technology, 5G, and big data) into high-efficiency learning behaviors during AI-assisted teaching reform. They should also provide essential special training to improve their ability to master the leading learning technologies.

5 Conclusions

Based on the literature review, the influences of five aspects of AIED on teaching effectiveness were analyzed in this study. Moreover, the mediating effect of teachers' perceptions of ET for AIED to improve teaching effectiveness was estimated. Differences in teaching effectiveness among learners with different AI-using periods were investigated. Some major conclusions could be drawn: (1) the overall Cronbach α and KMO of the questionnaire are 0.907 and 0.878, respectively, and χ^2 of Bartlett's test of sphericity reaches the 0.01 significance level. (2) AI-assisted teaching, exercise, exam, and assessment have significant influences on the improvement of teaching effectiveness. (3) Teachers' perceptions of ET provide some mediating effects for AIED to promote the improvement of teaching effectiveness. (4) Samples with different AI-using periods all have significant influences on teaching effectiveness (p < 0.01). Further studies are still needed in terms of teachers' efforts in meeting the learning needs of students by using different intelligent measures and the imagination that AI gives to students about learning interests and hobbies, design, research, and development of AI-assisted teaching systems.

6   References

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7   Author

Hualiang Lin, master's degree, associate professor at the School of Tourism Service and Management, Zhejiang Tourism College. His research interests focus on electronic commerce and tourism education (Email: lhl@tourzj.edu.cn).