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The level of perceived efficacy from teachers to access AI-based teaching applications

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Abstract

The purpose of this study is to develop the 'Teachers' Efficacy Perceptions of the AI-based Teaching Applications (TEP-AITA) scale' and to describe the analysis of the background variables and the differences between six factors in the application of an Artificial Intelligence (AI) teaching efficacy perceptions questionnaire. In total, 714 vocational senior high school teachers participated in random and cluster sampling in Taiwan. The results showed that the internal consistency reliability of the measure was .988 and that the reliability of the six subscales was .975, .971, .981, .976, .972, and .967. The results found that TEP-AITA scale included 'Resource support', 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', 'Learner demand', and 'Self-reflection'. 'Cross-disciplinary' and 'Learner demand' were highly rated, while 'Resource support' was low. This study analyzed the differences in the perceived efficacy for AI-based teaching applications among teachers according to their background variables, such as their gender, current position, school attributes, teachers' seniority, and application AI teaching experience. The research results on teacher background factors and the six factors of the TEP-AITA scale could be provided to education units for the active promotion of AI information technology teaching and training.

Keywords: Artificial intelligence (AI), Teachers' Efficacy Perceptions of AI-based Teaching Applications (TEP-AITA), Innovative teaching, Cross-disciplinary, Professional learning

Introduction

The emergence of innovative technologies has an impact on the methods of teaching and learning. With the rapid development of artificial intelligence (AI) technology in recent years, using AI in education has become more and more apparent (Huang et al., 2021). According to various international reports, Artificial Intelligence in Education (AIEd) is one of the currently emerging fields in educational technology (Weiss et al., 2022; Zawacki-Richter et al., 2019). Tahiru (2021) indicates that AI in education is already implemented and in use in the United States of America (USA), Japan, and other developed countries. With advancements in AI, higher education has begun to adopt new technologies. The global AI market's estimated compound annual growth rate (CAGR) between 2018 and 2025 differs from 33% to 55%. By 2025 the AI global market is projected to be worth between 156 and 360 billion Euros (Dirksen & Takahashi, 2020; Weiss et al., 2022). The AI market size in the education sector in the USA. has the potential to grow by US$253.82 million during 2021-2025, and the market's growth momentum will accelerate at a CAGR of 49.22% (Technavio, 2021). AI is currently progressing at an accelerated pace, and this already impacts the profound nature of services within higher education (Fahimirad & Kotamjani, 2018).

With the thrive of AI technology, its applications in education have been increasing, with promising potentials to provide customized learning, to offer dynamic assessments, and to facilitate meaningful interactions in online, mobile, or blended learning experiences. More provocatively, in response to the teacher shortage in the USA, for example, one proposal is to replace some roles of teachers with robots and AI (Zhang & Aslan, 2021). Huang et al. (2021) study the application of AI in the field of education, such as adaptive learning, teaching evaluation, virtual classroom, etc. They then analyze its impact on teaching and learning, which has a positive meaning for improving teachers' teaching level and students' learning quality.

There is a looming crisis caused by the negative population growth in 2020 and the serious threat of enrollment 1.7% reduction per year in vocational schools (NIKKEI ASIA, 2021; Taipei Time, 2021; The News Lens, 2022). The industrial structure has gradually turned towards creating a cross-industry integrated economy with a high output value (Taiwan News, 2021). Emerging technology trends, such as AI and the Internet of Things, must be cultivated by vocational education to provide people with excellent problem-solving skills, innovative decision-making skills, and good judgment (Chen & Hengjinda, 2019; Yeh et al., 2021; Zanzotto, 2019). The Taiwan Ministry of Education is promoting the AI trend, with core literacy as its main axis of development, with the aim of cultivating citizens who can adapt to the current life and future challenges. The core competencies are knowledge, ability, and attitude (Asthana & Gupta, 2019; Asthana & Hazela, 2020; Taiwan Artificial Intelligence School, 2019; Taiwan Industrial Technology Research Institute, 2021). The Taiwan AI Action Plan includes information technology (IT) courses in primary and secondary schools, with cognitive experience and interest in AI and emerging technologies, as well as AI-specific courses in the overall AI talent cultivation plan (Chen & Hengjinda, 2019; Colombo et al., 2019; Taiwan Industrial Technology Research Institute, 2021).

The AI trend is the concept of whole-person education, which provides students with broad and relevant learning and achieves integrated learning through the development of a knowledge structure, social change, and intellectual innovation (Colombo et al., 2019; Esch et al., 2019; Guerrero-Roldán et al., 2021; Kong, 2021). Research into a new domain of AI in education must be intensified, and educators must revise the educational curriculum at various levels (Tahiru, 2021). There are some challenges for teachers in vocational senior high schools, with regard to the professionalization of teaching in the face of the AI education trend (Chen et al., 2020; Guan et al., 2020; Huang et al., 2021; Liu & Wang, 2020).

First, the emphasis is on core literacy, which is different from the teaching of vocational skills. Teachers adopting resource support and innovative teaching in AI application course curriculum design can translate into an actual executable teaching activity. Using AI platforms, instructors have been able to perform different administrative functions, such as reviewing and grading students' assignments more effectively and efficiently, and achieve higher quality in their teaching activities (Chen et al., 2020; Guan et al., 2020; Zawacki-Richter et al., 2019).

Second, professional teacher training in AI applications focuses mainly on cultivating teachers who attach importance to student learning, who possess professional knowledge, affection, and attitude, and who gradually develop the individual potential of students to achieve their appropriate educational goals and develop their talents. In terms of AI applications in professional learning and learners' demands, the AI systems that leverage machine learning and adaptability, curriculum, and content have been customized and personalized in line with students' needs. They have fostered uptake and retention, thereby improving learners' experience and overall quality of learning (Chen et al., 2020; Liu & Wang, 2020).

Third, teachers who master the concepts of cross-disciplinary and self-reflection in the teacher-training stage develop an expertise in cross-disciplinary skills and have more than two areas of expertise, in order to cultivate their AI teaching ability. Professional service teachers are connected to knowledge nodes in literacy teaching to produce their innovative teaching ability and self-reflection (Huang et al., 2021; Liu & Wang, 2020).

Teachers' AI education teaching and application

Researchers believe that the application of AI education focuses on using AI technology in teaching problem analysis. For example, as an assistant teacher and analyst in classroom teaching, AI has greatly contributed to the high efficiency, accuracy, and diversity of teaching (Liu & Wang, 2020). The AI teaching process, from AI skills and knowledge education to AI education, is to guide, enhance, and promote students' curiosity and potential. The growth of students' AI application is also the biggest task and mission of AI education (Liu & Wang, 2020; Xia, 2019).

Cook et al. (2018) indicate that a teacher's AI education application aims to emphasize the precise understanding of students' psychology and learning status, to diagnose their learning problems and needs, and then to provide teaching interventions and AI or big data to provide an accurate diagnosis and understanding of their learning problems. The ability of the AI education application and learning mechanism is based on the stages of diagnosis, prediction, guidance, and prevention of 'precision education' (du Boulay, 2016; Fahimirad & Kotamjani, 2018; Guilherme, 2019). Nqoc and Van (2021) propose an AI system platform that detects students' sexual orientation and the best learning style through AI, which can use Bloom's thinking levels and Gardener's categories of multiple intelligence, and the school can detect students' aptitudes and the best learning methods to help guide them in their learning (Mozer et al., 2019). Teachers could use AI education applications to combine information and communications technology (ICT) and AI technologies, to construct a teaching platform, to provide virtual or real teaching situations, and to improve students' abilities (Nakata, 2019; Simonov et al., 2019).

The theory of knowledge construction

The knowledge construction theory emphasizes the initiative of learners and notes that learning is the process by which learners generate meaning and construct understanding, based on their original knowledge and experience, and that this process is often formed in an innovative teaching and social cultural interaction (Kahn & Winters, 2021). A teacher's AI education application ability, based on the knowledge construction theory, lies in the teacher's participation in the school's AI education application practice of cross-disciplinary (Tan et al., 2021; Tang et al., 2021). Teachers play a key role in improving students' learning effectiveness and developing their cooperative learning, and AI knowledge-ability teaching also plays a key role (Cope et al., 2020). Teachers' AI education applications have been coupled with educational epistemology in different disciplines or environments (Kong, 2021; Nakata, 2019; Tan et al., 2021; Tang et al., 2021; Tuomi, 2018). AI technology knowledge reconstruction is conducted through AI teaching practice across different subject areas and interactions of education expertise with AI education application knowledge. From the above, the activities of knowledge construction and transformation of ICT information into the process of innovative teaching knowledge through cross-domain processing become the methods of teachers' personal construction of knowledge.

The knowledge construction theory explores the demand analysis and professional learning of teachers using AI in teaching. Their role is to generate new AI teaching knowledge for students in the school organization and for the students to show that this knowledge can be used in daily practice to reconstruct and develop AI learning (Guggemos & Seufert, 2021). School knowledge construction pedagogy implements knowledge construction in the classroom (Muhie & Woldie, 2020). From learners' demands and professional learning, Ouyang and Jiao (2021) propose AI-directed, AI-supported, and AI-empowered paradigms for AIEd. Kahn and Winters (2021) offer that an ideal future involves a synthesis of these two schools of AI. Students not only can choose between computational building blocks that are symbolic or neural but also can use a current topic hybrid of AI research. Overall, the development trend of AIEd has been to empower learner agency and personalization, enable learners to reflect on learning, inform AI systems to adapt accordingly and lead to iterative development of learner-centered, data-driven, personalized learning.

The knowledge construction theory explores the resource support and self-reflection of teachers using AI in teaching. Teachers need to apply AI resource support for problems in the time sequence of the teaching process. They are sometimes unable to complete the AI teaching activity design and are conscious that their original abilities, materials, and information are insufficient. They also fail to provide sufficient teaching resources to fill the gap that is formed by the discontinuity of information (Cox & Prestridge, 2020; Darling-Hammond et al., 2020). Chounta et al. (2021) state that teachers need support in order to be efficient and effective in their work practice, and we envision that AI can be used to provide this support. Three sources of regulation play a role in knowledge construction when learning to teach: external sources provide new information, active internal sources deliberately focus on (new) information, and dynamic internal sources spontaneously reconceptualize prior understandings (Oosterheert & Vermunt, 2003).

Reflective practice is associated with a combination of professional education and practical knowledge. Being a reflective practitioner requires the ability and inclination to translate concepts into action, as well as the ability to embed oneself in the 'real world' of practice. This process of examining oneself is an important part of developing self-knowledge, which involves a critical investigation of one's beliefs, thoughts, and behaviors. Therefore, the theory of knowledge construction reflects the relationship between teachers' reflective practice and resource support cognition, as well as the relationship between the teachers' personal epistemological model. The purpose is to fill the application of the AI teaching information gap or to solve the teaching problems.

Teachers' efficacy perceptions of AI-based teaching applications

In an AI teaching application environment, schools are using the process virtualization theory in an increasingly virtual AI society (Zamora-Antuñano et al., 2022). Teachers could teach and learn virtually through ICT mechanisms. For example, students could register and pay online, learn in MOOC digital classes, and discuss what they have learned on social platforms (Mavrikis et al., 2019). The phenomenon of 'process virtualization' includes formal education (through distance learning), shopping (through e-commerce), and friendship development (through social networking sites and virtual worlds). Among them, as far as the education process is concerned, distance learning is developing faster than other teaching processes, and e-commerce is often used in the daily shopping process (Mozer et al., 2019; Oberländer et al., 2020).

Teachers' AI education application aims to differentiate between the concept of a heterogeneous network and other network theories and to include not only people but also objects and organizations (Shiohira, 2021). At that time, AI application education activities will be affected, showing that teachers' AI education application ability is still based on their professional teaching ability (Lez'er et al., 2019). Oberländer et al. (2020) and Sahin and Yilmaz (2020) proposed the role and function of teachers using AI education applications that are Automation, Integration, Acclimation, Content description (Delineation), and Identification. It can be seen from the above that teachers' efficacy perceptions of AI-based teaching can include resource support, innovative teaching, cross-disciplinary, professional learning, learner demand, and self-reflection. The definition are as follows (Chounta et al., 2021; Sahin & Yilmaz, 2020; Tussyadiah & Miller, 2019; Wang & Wang, 2022; Werner-Seidler et al., 2017; Yeh et al., 2021).

(1) Resource support: The teaching resources needed to establish the steps and mechanisms of AI technology learning tasks that students need to complete. AI solutions can be integrated with IT plans (such as smart technology and IoT-driven networks) to provide students with personalized learning solutions (Chounta et al., 2021; Oberländer et al., 2020; Sahin & Yilmaz, 2020).

(2) Innovative teaching: Various tasks for the development of AI technology, such as collection, design, creative production, persuasion and rules, and other tasks. By automating tasks such as scoring, number classification, or timetable arrangements, teachers can increase their time of interaction with students (Tussyadiah & Miller, 2019; Yeh et al., 2021).

(3) Cross-disciplinary: Things teachers provide to students on AI technology and cross-disciplinary learning content so that students can understand the learning results and apply the learned experience to other life situations. The proportion of students using smartphones is high. Schools can use mobile phones to conduct AI courses to help them adapt to the emerging technological changes (Oberländer et al., 2020; Sahin & Yilmaz, 2020).

(4) Professional learning: Students need to achieve the learning goals and the list of applicable AI technology materials, professional judgments, and a systematic teaching design (Chounta et al., 2021; Sahin & Yilmaz, 2020).

(5) Learner demand: Teachers are provided with the students' backgrounds and the purpose of the relevant teaching topics before the teaching activities, in order to stimulate their motivation to learn and explore. The needs of students and the priority

of the course are for teachers to ensure that the teaching content provided is relevant to emerging technologies. Through AI and learning analysis, teachers can identify students' learning problems, which can help them to design an effective classroom experience (Oberländer et al., 2020; Sahin & Yilmaz, 2020).

(6) Self-reflection: Teachers consider the relevance of learning abilities and teaching goals required by various AI technologies, so that students could conduct self-assessments and evaluate their learning content and learning results. AI can help teachers to discover and correct the potential learning problems of students in the formation stage. Teachers can effectively help to identify the keys to student learning, based on the data analysis provided by AI solutions (Sahin & Yilmaz, 2020; Werner-Seidler et al., 2017).

In terms of an assessment measure of teachers' efficacy perceptions of AI-based teaching applications, Tussyadiah and Miller (2019) find that the effectiveness of using AI for positive behavior change interventions depends on consumers' attitudes toward AI. Their study notes three underlying views of AI impacts: Beneficial AI, Destructive AI, and Risky AI. Tang and Austin (2009) examine business students' perceptions of four objectives (i.e., Enjoyment, Learning, Motivation, and Career Application) across five teaching technologies (i.e., Projector, PowerPoint, Video, the Internet, and Lecture), business professors' effective application of technologies, and students' academic performance. Wang and Wang (2019) develop 'The AI Anxiety Scale (AIAS)', which is aimed at four factors (L: learning, J: job replacement, S: sociotechnical blindness, and C: AI configuration). The reliability of each aspect of the AI scale developed by Wang and Wang (2019) is 'learning' ($\alpha = 0.974$), 'job replacement' ($\alpha = 0.917$), 'sociotechnical blindness' ($\alpha = 0.917$), and 'AI configuration' ($\alpha = 0.961$). Chai et al. (2021) develop a survey questionnaire to measure behavioral intention to learn AI. The five factors are self-efficacy in learning AI, AI readiness, perceptions of the use of AI for social good, AI literacy, and behavioral intention. Tan et al. (2021) draw from the Knowledge Building model to discuss alignments for knowledge creation in seven areas: views of knowledge, 21^{st}-century educational competencies, education and equity, pedagogy and technology integration, assessment, learning and collaboration, teacher learning, and student learning outcomes.

Based on the above, it can be seen that teachers judge the effectiveness of AI products and that they consider certain standards, such as accuracy, content creativity, and readability. Learning based on an AI inquiry could help carry out curriculum integration, cooperative teaching, and integrated teaching strategies of ICT technology, which could then help to improve students' critical thinking skills.

Research questions

Based on the above, the teaching ability of a teacher should be combined with industrial needs and new international knowledge to capture the future direction and information of the AI industry (Chounta et al., 2021; OECD, 2019). It is important that teachers should pay attention to the AI teaching trend. Therefore, this research develops a 'Teachers' Efficacy Perceptions of AI-based Teaching Applications (TEP-AITA) scale' and describes an analysis of the background variables and the differences between the six factors in a TEP-AITA questionnaire. The questions of this study are to address the following two issues.

1. What is the development process and factors of the TEP-AITA scale?
2. What are the differences in the TEP-AITA scale based on teachers' background variables such as teachers' gender, school attributes, positions, qualifications, and AI-based teaching experience?

Methodology

Participants

This study's participants were 714 teachers of 23 publics and 22 private vocational senior high schools. For the sampled objects, according to the data published by the Taiwan Statistics Department of the Ministry of Education (2019a, 2019b), 8605 classes of professional subjects from national public and private high schools were included in the scope of this study. These included 304 agriculture classes, 3268 industrial classes, 2607 business classes, 2083 classes in family affairs, 70 maritime classes, and 273 drama classes. Participants were chosen if teachers had applied AI technology in their teaching experience and used a random and cluster sampling method. Teachers were stratified for the regional educational network in accordance with their basic information (e.g., gender, position, school attributes, teachers' seniority, and application in AI teaching experience). In total, 800 questionnaires of the scale were distributed, and 714 effective questionnaires were returned for a response rate of 89.3%. Following Krejcie and Morgan (1970), the minimum effective sample size was 354. Participants gave their informed consent before the study commenced, and their background is shown in a formal scale in Table 1. From Krejcie and Morgan (1970), the minimum effective sample size formula is as follows.

$$ni = \frac{X^2 NiP (1 - P)}{d^2 (Ni - 1) + X^2 P (1 - P)} \qquad ni = \frac{3.84 \times 4321 \times 0.5 \times (1 - 0.5)}{0.05^2 \times (4321 - 1) + 3.84 \times 0.5 \times (1 - 0.5)} \fallingdotseq 354$$

Formula description:

ni: the sample size.

Ni: Number of sample parent groups.

P: Population proportion, P value set to 0.5 in the above formula will yield the maximum number of samples.

D: set to 0.05.

X^2: Under the chi-square distribution of a 95% confidence interval with a degree of freedom, its value is 3.84. Calculate the number of samples according to the above formula.

Research process

(1) The structure and composition of the TEP-AITA were defined

According to the literature analysis, TEP-AITA scale is a multi-dimensional construct that contains elements such as cognition, affection, and behavior. The TEP-AITA scale refers to Tussyadiah and Miller (2019) who list items representing benefits and risks of AI. Tang and Austin (2009) develop the 'Students' Perceptions of Technology Scale (SPOTS)'. This TEP-AITA scale was written the structure, composition, and trail statements, and modified teaching techniques of SPOTS and changed AI-based teaching technology. In terms of participants' background analyses, this TEP-AITA scale refers to the research results of SPOTS, it shows that students of different ages have different preferences for teaching technology. This research purpose refers to analyze teachers' background variables (gender,

Table 1 Distribution of participants' background in TEP-AITA formal scales (N = 714)

Basic information	Group	No of people	%
Gender	1. Male	362	50.8
	2. Female	352	49.2
Position	1. Executive staff	158	22.2
	2. Teachers	288	40.3
	3. Teachers & administrators	268	37.5
School attributes	1. Public	392	54.8
	2. Private	322	46.2
Teachers' seniority	1. Below 10 years	296	41.5
	2. 11 years - 20 years	334	46.9
	3. 21 years - 30 years	44	6.2
	4. More than 31 years	40	5.4
Application AI teaching experience	1. No	214	30.0
	2. 1 year- 3 years	258	36.1
	3. More than 3 years	242	33.9

school attributes, job position, seniority, and application AI teaching experience). Wang and Wang (2019) set up 'The AI Anxiety Scale (AIAS)'. Tussyadiah and Miller (2019) use an online questionnaire to capture travelers' perceptions of the impacts of intelligent systems (including AI and robotics) in society. A list of items representing the benefits and risks of AI implementation was developed from comprehensive industry research on consumer perception of AI. The list consists of 13 items representing benefits and 13 items representing risks of AI. Tang and Austin (2009) built the Students' Perceptions of Technology Scale (SPOTS), which aims at five teaching techniques and four learning goals (enjoyment, learning, motivation, and career application) and includes projectors, PowerPoint, video, Internet, and lectures. This study refers to the SPOTS scale for three reasons, namely: First, the TEP-AITA scale of the structure, composition and clues refer to the four learning objectives and five learning technologies in the SPOTS questionnaire. This TEP-AITA modified teaching techniques of SPOTS and changed AI-based teaching technology. However, the successful implementation of new instructional technologies is closely related to the attitudes of the teachers who lead the lesson. Second, this TEP-AITA scale refers to the research results of SPOTS, indicating that participants have different preferences for teaching technology due to their different backgrounds. This research purpose refers to analyze teachers' background variables (gender, school attributes, job position, seniority, and application AI teaching experience) and the differences between six factors in a TEP-AITA scale. Third, this paper refers to other scholars' measurements for evaluating teachers' learning experience, such as Tang and Austin (2009), Wang and Wang (2019), Zhang and Aslan (2021), and Nazaretsky et al. (2022). Wang and Wang (2019) develop the 'AI Anxiety Scale (AIAS)' with aspects of learning, job replacement, sociotechnical blindness, and AI configuration. According to the scholars' views, the TEP-AITA scale measurement content covers the six subscales of 'Resource support', 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', 'Learner demand', and 'Self-reflection'.

(2) Trial statements were written

The questionnaire was designed to understand the teachers' efficacy perception on the application of AI in teaching in the new national curriculum and, in response to their possible resistance, to solve and collect their suggestions. It is important to identify teachers' cognitive efficacy regarding the need for AI application in teaching and their awareness of the AI technology development trends. The questionnaire used in this study refers to Tang and Austin (2009), Wang and Wang (2019), Zhang and Aslan (2021), and Nazaretsky et al. (2022) for evaluating the teacher experience of learning. The questions were developed according to the measurement content of the subscales. The TEP-AITA scale had ten questions for each subscale of the development and application of the AI application teaching demand scale. Therefore, there were 50 questions in the first draft of the entire scale. The narratives were positive and arranged in a random manner.

(3) The measurement format was decided

Teachers' efficacy perceptions of AI-based teaching applications were required to be measured indirectly by each respondent's self-reports. Therefore, the TEP-AITA scale also adopted the Likert 5-point design format. In scoring, those who chose 'strongly agree' were given five points, those who chose 'agree' were given four points, those who chose 'neutral' were given three points, those who chose 'disagree' were given two points, and those who chose 'strongly disagree' were given one point.

(4) Experts evaluated the content validity of the first draft of TEP-AITA

After the completion of the first draft of the scale, according to TEP-AITA, the six subscales defined by the content of the TEP-AITA scale were reviewed to confirm that the textual description of each topic was appropriate and clear and to establish its content validity. The questionnaire used in this study was revised, and the validity of the expert content was confirmed before the pre-test. The surface validity of each question in the questionnaire was judged by six teachers/directors. The teachers/directors were divided into three groups: (a) full-time teachers of professional subjects with more than five years of teaching experience; (b) expert teachers in schools; and (c) those with administrative or industry work/internship experience. The items in the questionnaire were modified, and the meanings of the sentences were described. Three vocational and technology education course experts participated in the review.

(5) A pilot test and revision of the first draft of the TEP-AITA scale were carried out

The first draft of the TEP-AITA scale was tested by 122 vocational senior high school teachers and was revised according to the test results. After analysis of the test questions, those with corrected item-total correlation values of less than 0.30 were excluded, according to the commonly-used criteria. Based on the principal factor method of 122 pre-sampling, after obliquely turning the axis and taking the eigenvalues greater than 1, 27 items in total were obtained and six subscales were named: (1) Resource support (5 items, Cronbach's α = .975). For example, AI teaching materials and free AI teaching resources could solve the problem of AI teaching resources; (2) Innovative teaching (4 items, Cronbach's α = .971). For example, applying AI teaching resources could make students feel novel; (3) Cross-disciplinary (4 items, Cronbach's α = .981). For example, application AI in Teaching could feel the need for the cross-field application of IT and teaching profession; (4) Professional learning (5 items, Cronbach's α = .976). For example, teacher application AI in teaching activities could reflect professional learning; (5) Learner demand (5 items, Cronbach's α = .972). For example, AI allows large-scale personalized customized services and tutoring, which helps to meet the learning needs of students; and (6) Self-reflection (4 items, Cronbach's α = .967). For example, teachers consider students' use of AI attitude to reflect the application of AI in teaching. The developed scales for each dimension adapted or referenced research instrument and the reliability of the TEP-AITA scale, as show in Table 2.

(6) The data were analyzed

In order to analyze the relationship between TEP-AITA and the influence variables, this

Table 2 Each dimension adapted or referenced research instrument and the reliability of TEP-AITA scale

Factor	Definitions	Referenced research and adopted instrument	Cronbach's α
Resource support	The teaching resources needed to establish the steps and mechanisms of AI technology learning tasks that students need to complete. AI solutions can be integrated with IT plans (such as smart technology and IoT-driven networks) to provide students with personalized learning solutions.	Chounta et al., 2021; Oberländer et al., 2020; Sahin & Yilmaz, 2020; Wang & Wang, 2019; Tussyadiah & Miller, 2019	.975
Innovative teaching	Various tasks for the development of AI technology, such as collection, design, creative production, persuasion and rules, and other tasks. By automating tasks such as scoring, number classification, or timetable arrangements, teachers can increase their time of interaction with students.	Tang & Austin, 2009; Tussyadiah & Miller, 2019; Yeh et al., 2021	.971
Cross-disciplinary	Things teachers provide to students on AI technology and cross-disciplinary learning content so that students can understand the learning results and apply the learned experience to other life situations. The proportion of students using smartphones is high. Schools can use mobile phones to conduct AI courses to help them adapt to the emerging technological changes.	Oberländer et al., 2020; Sahin & Yilmaz, 2020; Tussyadiah & Miller, 2019; Wang & Wang, 2019	.981
Professional learning	Students need to achieve the learning goals and the list of applicable AI technology materials, professional judgments, and a systematic teaching design.	Chounta et al., 2021; Sahin & Yilmaz, 2020; Tang & Austin, 2009	.976
Learner demand	Teachers are provided with the students' backgrounds and the purpose of the relevant teaching topics before the teaching activities, in order to stimulate their motivation to learn and explore. The needs of students and the priority of the course are for teachers to ensure that the teaching content provided is relevant to emerging technologies. Through AI and learning analysis, teachers can identify students' learning problems, which can help them to design an effective classroom experience.	Oberländer et al., 2020; Sahin & Yilmaz, 2020; Tang & Austin, 2009; Wang & Wang, 2019	.972
Self-reflection	Teachers consider the relevance of learning abilities and teaching goals required by various AI technologies, so that students could conduct self-assessments and evaluate their learning content and learning results. AI can help teachers to discover and correct the potential learning problems of students in the formation stage. Teachers can effectively help to identify the keys to student learning, based on the data analysis provided by AI solutions.	Sahin & Yilmaz, 2020; Tussyadiah & Miller, 2019 Wang & Wang, 2019; Werner-Seidler et al., 2017	.967
		Total	.988

study used the SPSS statistical software package. The statistical analysis used descriptive statistics, reliability analysis, exploratory factor analysis, and multivariate analysis of variance (MANOVA).

Research results

Analysis of questions

The results were appropriate that questions' correlation between each item and total score of subscale were more than 0.30 in the TEP-AITA scale. In addition, there were no significant changes in the internal consistency of the overall TEP-AITA test (expressed as Cronbach's α) after the scores of the test were listed. It could be seen that the test questions were consistent with the internal scale of the test. The six subscales indicated that the direction measured by each test included in the TEP-AITA scale was consistent with that measured by the entire scale.

Reliability test

The data showed that the internal consistency reliability of the TEP-AITA scale (expressed as Cronbach's α) was .988, and the Cronbach's α reliability coefficients of the six subscales (S1~S6) were respectively .975, .971, .981, .976, .972, and .967, three of which were between 0.967 and 0.981, indicating the TEP-AITA scale and the six subscales exhibited appropriate internal consistency. The analysis results showed that the correlation coefficient between the total score of the TEP-AITA scale and the scores of the six subscales was 0.85~0.93 ($p < 0.01$) and that the cross-correlation value between the scores of the six subscales was also 0.65~0.79. This is enough to show that TEP-AITA is indeed an assessment tool with appropriate internal consistency reliability.

Validity test

This study tested the validity of TEP-AITA according to its content validity, its simultaneous validity, and its construct validity. As mentioned in the research process, at the beginning of the development, TEP-AITA first focused on the structure of the AI teaching efficacy regarding resource support, innovative teaching, cross-disciplinary, and professional learning. Six subscales, including learner demand and self-reflection, were analyzed in the form of a literature discussion, and then each test case was written to form six pairs of the TEP-AITA scales. After the completion of the first draft, an expert meeting was held, where experts reviewed the content and the textual narrative of each topic to decide whether the positive and negative tendencies had appropriate content validity.

Factor analysis

In order to take the construct validity of TEP-AITA, this study analyzed the relevant literature as the basis for the development of the TEP-AITA construct and adopted a rigorous test development process according to the recommendations of the scholars. In addition to synthesizing the above-mentioned reliability and validity test process and results, as part of the interpretation and testing of the construct validity, this study analyzed the factor structure of TEP-AITA by using principal component analysis. The Kaiser-Meyer-Olkin measure of sampling adequacy had a value of 0.979, and the Bartlett test of sphericity had a value of 35,353.11, which reached a significant level (degrees of freedom of 714). The statistics showed that the data in this study were quite suitable for factor analysis. It was also found when the score of TEP-AITA was judged by the screen test that the cumulative variation explanatory of six factors was 69.58%. The eigenvalues of the TEP-AITA scale were 4.27, 3.12, 3.17, 4.50, 4.37, and 3.22, and the total explanatory variables were 17.80%, 12.79%, 12.96%, 9.71%, 9.62%, and 6.7%, as shown in Table 3.

The perceived situation of the TEP-AITA scale

As can be seen in Table 3, the research results showed a positive attitude on the TEP-AITA scale. The measure had six subscales, which included resource support (5 items, M = 3.30), innovative teaching (4 items, M = 3.64), cross-disciplinary (4 items, M = 3.96), professional learning (5 items, M = 3.69), learner demand (5 items, M = 3.88), and self-reflection (4 items, M = 3.59). The views of the teachers from technical colleges on the professionalism of application AI teaching were higher than their recognition of cross-domain professionalism and learner demand; on the other hand, their recognition of resource support was relatively low. The reason was that the application of AI technology in education was still in its infancy. Teachers need less AI teaching content for new courses, and there was relatively low demand. In the future, AI education applications in teaching,

Table 3 Descriptive statistics and factor analysis of TEP-AITA scale

Factor	No.	M	SD	Sort	Eigen values	Explaining the amount of variation (%)	Cumulative explanatory variation (%)
Resource support	5	3.79	.82	6	4.27	17.80	17.80
Innovative teaching	4	3.89	.77	4	3.12	12.79	30.59
Cross-disciplinary	4	4.25	.68	1	3.17	12.96	43.55
Professional learning	5	3.92	.75	3	4.50	9.71	53.26
Learner demand	5	4.17	.58	2	4.37	9.62	62.88
Self-reflection	4	3.85	.68	5	3.22	6.70	69.58
Total	27	3.674	.608				

Note: 1. KMO value = .884, Bartlett's spherical test x2 = 2575.127, the rotation axis converges to 8 iterations.

such as personalized learning, smart learning feedback, and robot remote teaching support, should also be promising. With the advancement of AI technology, its application in the field of education may deepen in the future, and the needs of teachers will change.

The analysis of background variables and the differences between six factors in a TEP-AITA scale

As shown in Table 4, the analysis of background variables and the differences between six factors in the TEP-AITA scale were for resource support, innovative teaching, cross-disciplinary, professional learning, learner demand, and self-reflection, all of which reached significant differences. This study further analyzed the differences in the professional demand for AI application teaching among teachers according to their background variables, such as their gender, current position, school attributes, teachers' seniority, and application AI teaching experience.

(1) Teachers' gender

The gender differences on six subscales were tested by MANOVA, and the results are shown in Table 3. The Wilk's λ test reached a significant level (Wilk's $\lambda = .912$, $p < 0.001$), indicating that teachers of different genders have significant differences in their overall level of TEP-AITA ($\eta2 = .022$). It is seen that the intensity of the effect of gender on TEP-AITA is .022. 'Innovative teaching' ($F = -. 086$, $p < 0.001$) reached significant levels for the gender differences. After the test, it was learned that those of male teachers were significantly higher than those of female teachers. There was no gender difference when the 'Resource support', 'Cross-disciplinary', 'Professional learning', 'Learner demand', and 'Self-reflection' factors did not reach a significant level.

(2) Job position

The difference of the job position in the six subscales was tested by using MANOVA. The results are shown in Table 5. The Wilk's λ test reached a significant level (Wilk's $\lambda = .642$,

Table 4 Difference test between male and female teachers in TEP-AITA

Factor	Male (N = 181)		Female (N = 176)		*F* Value
	M	*SD*	*M*	*SD*	
Resource support	3.98	0.92	3.71	0.81	-3.634
Innovative teaching	4.36	0.91	3.68	0.89	-0.086***
Cross-disciplinary	3.92	0.89	3.62	0.95	2.971
Professional learning	3.84	0.91	3.75	1.01	-2.860
Learner demand	3.71	0.93	3.69	0.88	2.285
Self-reflection	3.69	0.79	3.77	0.89	3.118

Wilk's λ = .912 *Multivariate F = 11.213**

**p < 0.05   ***p < 0.001*

Table 5 Difference test among teachers' job position in TEP-AITA

Factor	1. Executive staff (N = 97)		2. Teachers (N = 144)		3. Teachers & administrators (N = 134)		*F* Value	*Scheffe's test*
	M	*SD*	*M*	*SD*	*M*	*SD*		
Resource support	4.22	0.98	3.98	1.12	4.16	0.90	35.781***	1 > 2 3 > 2
Innovative teaching	4.35	1.09	3.85	1.07	4.18	1.12	13.965***	1 > 2 3 > 2
Cross-disciplinary	4.26	1.11	3.79	1.01	4.03	0.98	3.083***	1 > 2
Professional learning	4.23	0.89	3.60	0.96	3.82	1.02	21.205***	1 > 2
Learner demand	3.87	1.02	3.56	0.87	3.82	0.97	1.899	*ns.*
Self-reflection	4.23	0.99	3.55	1.01	3.67	1.11	12.121***	1 > 2 1 > 3

Wilk's λ = .643 *Multivariate F = 11.742*

**p < 0.05 ***p < 0.001*

p < 0.001), indicating that teachers in different job positions have significant differences of TEP-AITA (η2 = .032). The effect of the intensity of teachers' job positions on TEP-AITA was .032. When comparing the job position, there are differences in 'Resource support' (F = 35.781, p < 0.001), 'Innovative teaching' (F = 13.965, p < 0.001), 'Cross-disciplinary' (F = 3.083, p < 0.001), 'Professional learning' (F = 21.205, p < 0.001), and 'Self-reflection' (F = 12.121, p < 0.001). The five factors exhibit significant differences in job position, and 'Executive staff' was higher than 'teachers'. Only the 'Learner demand' (F = 1.899, p >0.05) factor did not reach a significant difference in the job position.

(3) School attributes

Table 6 shows that the school attributes did not have significant differences in MANOVA (Wilk's λ = .925, p < 0.001), which indicates that the teachers had different school attributes in TEP-AITA. There were obvious differences on the whole level, and the intensity of the effect was .041 (η2). According to the different inspections of school attributes for the six factors, the one factor of 'Self-reflection' (F = 8.91, p < 0.001) for private teachers was significantly higher than that for public teachers. The school attributes showed the perception of private teachers was higher than that of public teachers in 'Self-reflection', but the other five factors did not reach a significant difference in school attributes.

Table 6 Difference test between public and private school attributes in TEP-AITA

Factor	1. Public (N = 196)		2. Private (N = 161)		*F* Value
	M	*SD*	*M*	*SD*	
Resource support	3.65	1.06	3.85	1.03	3.012
Innovative teaching	3.98	0.84	4.16	0.94	2.923
Cross-disciplinary	3.62	1.09	4.08	1.06	2.572
Professional learning	3.95	0.94	4.08	1.11	3.051
Learner demand	4.08	1.14	4.06	0.88	2.912
Self-reflection	3.65	1.22	4.24	0.92	8.910***

**p* < 0.05 ****p* < 0.001*

(4) Teachers' seniority

Table 7 shows that the MANOVA test of the difference in teachers' seniority reached a significant level (Wilk's λ = .503, p < 0.05), indicating that different levels of teachers' seniority had an obvious effect on the overall level of TEP-AITA (η2 = .041). Teachers' senior position effect on TEP-AITA was .041. When comparing the job position differences of the various factors, the results were as follows: 'Resource support' (F = 15.61, p < 0.001), 'Professional learning' (F = 21.205, p < 0.001), and 'Self-reflection' (F = 12.42.121, p < 0.001). The four factors that did not reach a significant difference were 'Innovative teaching' (F = 2.84, p >0.05), 'Cross-disciplinary' (F = 3.61, p >0.05), 'Learner demand' (F = 2.52, p >0.05), and 'Self-reflection' (F = 3.23, p >0.05). Teachers' seniority of '11 years - 20 years' was higher than those with '21 years - 30 years' and those with 'More than 31 years' in the 'Resource support' level of efficacy perceptions for the application of AI teaching. Teachers' seniority of 'More than 31 years' perceived demand was higher than those of between '21 years - 30 years' on 'Learner demand' for AI application teaching.

Table 7 Difference test among teachers' seniority in TEP-AITA

Factor	1. Below 10 years (N = 148)		2. 11 years - 20 years (N = 167)		3. 21 years - 30 years (N = 22)		4. More than 31 years (N = 20)		*F* Value	*Scheffe's test*
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
Resource support	3.91	1.11	4.27	1.01	3.68	1.01	3.78	1.13	15.61***	2 > 3 2 > 4
Innovative teaching	4.02	0.99	3.92	0.90	4.10	0.98	4.13	1.04	2.84	*ns.*
Cross-disciplinary	4.05	1.01	3.89	1.09	4.01	1.02	3.98	1.11	3.61	*ns.*
Professional learning	3.98	0.97	4.08	0.93	3.59	0.98	4.21	0.97	2.52	*ns.*
Learner demand	4.01	1.04	4.11	1.01	4.38	1.03	4.12	1.03	12.42***	4 > 3
Self-reflection	3.76	0.94	3.78	0.92	3.88	1.08	3.79	0.94	3.23	*ns.*

*Wilk's λ = .503 Multivariate F = 11.717**

p* < 0.05 * *p* < 0.001*

Table 8 Difference test among teachers' application AI teaching experience in TEP-AITA

Factor	1. No (N = 107)		2. 1-3 years (N = 129)		3. More than 3 years (N = 121)		*F* Value	*Scheffe's test*
	M	*SD*	*M*	*SD*	*M*	*SD*		
Resource support	4.12	0.97	3.98	1.13	3.86	1.01	1.878	*ns.*
Innovative teaching	3.95	0.88	4.05	1.03	4.01	1.12	3.073	*ns.*
Cross-disciplinary	3.92	1.11	4.19	1.08	4.23	0.96	36.771***	3 > 1 2 > 1
Professional learning	3.53	0.89	3.40	1.05	4.32	1.02	26.235***	3 > 2
Learner demand	4.01	1.01	3.92	1.11	3.98	0.98	2.071	*ns.*
Self-reflection	3.87	0.89	4.06	0.91	4.22	1.08	12.981***	2 > 1 3 > 2

Wilk's λ = .622 *Multivariate F = 18.742*

**p < 0.05 ***p < 0.001*

(5) Teachers' application of AI teaching experience

Table 8 presents that the teachers' application of AI teaching experience had a significant difference on MANOVA (Wilk's λ = .622, p < 0.001) in the overall TEP-AITA. There are obvious differences in the intensity of the effect (η2 = .067). Teachers' application of AI teaching experience reached a significant difference in 'Cross-disciplinary' (F = 36.771, p < 0.001), 'Professional learning' (F = 26.235, p < 0.001), and 'Self-reflection' (F = 12.981, p < 0.001). After Scheffe's test comparison, the AI teaching experience for a teacher of 'More than 3 years' was significantly higher than those with no AI teaching experience and those with '1 year - 3 years' AI teaching experience.

Discussion

This study was conducted to describe the analysis of the background variables and the differences between six factors in a TEP-AITA scale. Findings showed a significant difference relating to teachers' personal experience and ability and their working characteristics. The post-comparisons of the significant differences in TEP-AITA appear in Table 9.

First, male teachers had a higher 'Innovative teaching' demand perception of the application of AI teaching than female teachers. AI could also automate or semi-automate heavy and mechanical tasks, allowing teachers to focus more on innovative teaching (Du et al., 2020; Rahoo et al., 2021). In terms of the significant differences in 'Job position', 'Executive staff' and 'Teachers and administrators' were more aware of the changes in the overall environment of the school and administrative operations, and they had a higher

Table 9 The post-comparison of significant differences in TEP-AITA

Item		Resource support	Innovative teaching	Cross-disciplinary	Professional learning	Learner demand	Self-reflection	Total
Gender	1. Male		1 > 2					
	2. Female							
Position	1. Executive staff	1 > 2	1 > 2	1 > 2	1 > 2		1 > 2	1 > 2
	2. Teachers	3 > 2	3 > 2				1 > 3	3 > 2
	3. Teachers and administrators							
School attributes	1. Public						2 > 1	
	2. Private							
Seniority	1. Below 10 years	2 > 3				4 > 3		2 > 3
	2. 11 years - 20 years	2 > 4						
	3. 21 years - 30 years							
	4. More than 31 years							
Application AI teaching experience	1. No			3 > 1	3 > 2		2 > 1	3 > 2
	2. 1 year - 3 years			2 > 1			3 > 2	
	3. More than 3 years							

awareness of the professional demand for the application of AI teaching. The job position of 'Executive staff' and 'Teachers and administrators' was higher than 'Teachers' for the application of AI teaching demand on 'Resource support', 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', and 'Self-reflection'. In the education industry, AI is not only used to save teachers' manpower and improve teaching efficiency, but also to drive changes in their teaching methods. One can take AI-driven personalized education as an example, which collects students' homework, classroom behavior, exams, and other materials and makes a personalized diagnosis of the academic conditions of different students. Executive staffs' demand for remote teaching in schools has increased sharply, and information security issues have become more complicated. Information security protection has also been paid more attention. It has also prompted 'Executive staff' and 'Teachers and administrators' to see more demand for AI teaching than teachers (Cox, 2021).

Second, there were significant differences in terms of 'School attributes'. Private schools had enrollment and performance pressures, and teachers in private schools were oriented towards AI application teaching. The 'Self-reflection' perception of private school teachers was higher than that of public teachers. The reason for this was that teachers in private schools are under pressure with regard to their teaching effectiveness (Pan & Yu, 1999; Zhai et al., 2021). In terms of 'Self-reflection', it was necessary to consider the relevance of the learning abilities and teaching goals required by various AI technologies, so that students could conduct self-assessments and could evaluate the learning content and results of their learning. Teachers in private schools in Taiwan are more likely to think about themselves than teachers in public schools, because of the pressure of their appointment and the effectiveness of student learning. Teachers' self-reflection begins with the need to solve the problem of AI teaching, and the end goal is to improve the application of AI teaching to related courses, to comply with the changes in educational policies and social trends, and to promote the growth of teachers' subjects and digital teaching knowledge (Guerrero-Roldán et al., 2021; Sahin & Yilmaz, 2020).

Third, there were significant differences in terms of 'Teachers' seniority.' It was found that senior teachers pay more attention to the 'Learner demand' level of students, and teachers of '10 years - 20 years' pay more attention to 'Resource support' than senior teachers. The constructivist view of knowledge and learning is the creation of a certain environment and supports the promotion of the active construction of knowledge by learners. Senior teachers who have many years of teaching experience are full of confidence in their personal teaching abilities. They feel that they are more in demand for their level of understanding and application of learner demand. Teachers with '10 years - 20 years' of teaching experience often act as the main force in a school to promote emerging technologies in teaching. They are able to cooperate with schools in teaching reform and innovative teaching of emerging information technologies, causing them to promote and need more resources to support AI teaching. When comparing the differences in teacher seniority with each factor, the 'Resource support' factor of the '11 years - 20 years' teachers was significantly higher than those of other senior teachers. The four factors of 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', and 'Self-reflection' did not reach a significant difference in teaching background. This result shows that '11 years - 20 years' teachers have a higher demand for the application of AI teaching in 'Resource support', which proves the importance of having experienced professional teachers in the application of AI teaching.

Fourth, there were significant differences in terms of the 'teachers' application of the AI teaching experience'. The demand perception of the application AI teaching of teachers with more than 3 years' experience was higher than those with 'no teaching experience' and '1 year - 3 years' on 'Professional learning' and 'Cross-disciplinary'. Moreover, it is higher for teachers with more than three years of AI teaching experience than for teachers with less than three years of AI teaching experience on the 'Self-reflection' level (Rahoo et al., 2021). It can be seen that senior teachers may be better able to master and stimulate students to learn, because of the accumulation of their teaching experience. Teachers with many years of AI teaching experience are good at using Internet technology, at adopting innovative learning methods that are completely close to life, at inspiring students' hidden learning ability, and at making full use of their AI knowledge learning ability (Gravett & Kroon, 2021; Nielsen et al., 2020).

Conclusion

The purpose of this study was to explore teachers' efficacy perceptions of AI-based teaching applications using the TEP-AITA scale, which included six factors: 'Resource support', 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', 'Learner demand', and 'Self-reflection'. The analysis results indicated that the TEP-AITA scale developed by this research had good reliability. At the same time, it performed well in the validity test. The TEP-AITA scale could be used as a tool for teachers to assess the application of AI in teaching.

Result indicated the 'Innovative teaching' of male teachers was significantly higher than female teachers. It denotes that male teachers believe that there is still demand the application of AI teaching in the face of external AI teaching environment factors, that they try to satisfy students' interest in AI learning, and that their perceptual judgment was higher than that of female teachers. Result indicated executive staff were significantly higher than teachers in the five factors of 'Resource support', 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', and 'Self-reflection', and there was no significant difference in job position in the remaining one factor. This shows when they are engaged in information teaching and administrative computerization, their perceptions that could affect 'Resource support', 'Innovative teaching', 'Cross-disciplinary', 'Professional learning', and 'Self-reflection' levels were higher than those of the teachers. It further shows that executive staff and administrators are aware of the importance of promoting AI education in vocation education, and that their perception was higher than on resource support and innovative teaching of application AI teaching.

Findings indicated that teachers with different school attributes did not differ in the five efficacy perceptions of the application of AI teaching. Private school teachers' efficacy was higher than those of public school teachers only in the Self-reflection. When comparing the application of AI teaching experience to the differences of various factors, those of teachers with 'More than 3 years' of experience were significantly higher in the three factors of 'Cross-disciplinary', 'Professional learning', and 'Self-reflection' than the '1 year - 3 years' and 'no experience' teachers. The remaining three factors of 'Resource support', 'Innovative teaching', and 'Learner demand' did not reach significant differences in their application AI teaching experience. This shows that when a teacher of 'More than 3 years' has more experience in teaching AI, then there is a higher demand for 'Cross-disciplinary' and 'Professional learning', when AI was integrated into teaching. From this, it can be seen that if teachers' AI information technology was applied to their teaching knowledge, then the level of self-reflection awareness will relatively improve.

Implications and limitations

The TEP-AITA scale, as a measurement tool that was developed by this research, can reflect teachers' efficacy perceptions in the application of AI-based in teaching. It has its own theoretical research of knowledge construction and practical application of teachers' AI-based teaching. The research results on teacher background factors and the six factors of the TEP-AITA scale could be provided to education units for the active promotion of AI information technology skills and cross-field teaching training. The above research results could enhance teachers' AI teaching design knowledge, and they could use AI information technology to integrate into their teaching profession.

The research limitations are mainly based on the questionnaire survey method for collecting data to explore teachers' efficacy perceptions of AI-based teaching applications. First, teachers' efficacy perceptions of AI-based teaching applications may be affected by school-level factors, such as the atmosphere of organizational innovation. Future research could explore the impact of these factors on teachers' AI teaching needs. Second, the participants were limited by the teachers, such as their social expectations, defensive psychology, reaction attitude, answer fatigue, etc., which may affect the conclusions of the research results and lead to errors in the research. Third, this study points out that background variables, such as teachers' gender, current position, school attributes, teacher qualifications, and application of AI teaching experience, have differences in the perceived efficacy of teachers' AI-based teaching applications. It can be seen that teacher background is an influencing factor, which can be further examined in the future. Finally, although quantitative research methods could collect a large amount of data, they are unable to provide a deep understanding of its instructional beliefs. Therefore, this study suggests that future research could take the form of case studies, in which in-depth interviews can be conducted to understand the various factors relating to teachers' efficacy perceptions when applying AI to the current state of teaching in various subjects.

Abbreviations

AI: Artificial Intelligence; AIAS: AI Anxiety Scale; AIEd: Artificial Intelligence in Education; CAGR: Compound Annual Growth Rate; ICT: Information and Communications Technology; IT: Information Technology; SPOTS: Students' Perceptions of Technology Scale; TEP-AITA: Teachers' Efficacy Perceptions of the AI-based Teaching Applications.

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Authors' contributions

Each author listed above has made substantial contributions (data collection, data analysis and interpretation, draft, major revision of the article, and final approval of the version to be released) to the conception, design of the study, manuscript or substantively revised it. The author(s) read and approved the final manuscript.

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