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A competency-based framework for IT teachers: enhancing professional skills through AI algorithms and digital tools

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ABSTRACT

The rapid development of information technology has put forward higher requirements for teachers, and the traditional training model is difficult to meet the demand. The article constructs a teacher digital competency framework based on the ASTD model, realizes the division of teachers' professional competence, and explains the professional core connotation of teacher digital competency in detail. A personalized resource recommendation model for teachers is constructed using artificial intelligence technology, which provides accurate recommendations for teachers through candidate resource extraction and learning resource screening. At the same time, with the help of Google Cloud Services digital tools, the design of teachers' digital teaching and research activities was accomplished, and communication and cooperation with users in the virtual community was promoted. The combination of the two is integrated into the development of teachers' professional skills to enhance their teaching competence. The mean values of accuracy, applicability, timeliness, personalization, and diversity of learning resource recommendations under artificial intelligence technology ranged from 4.123 to 4.544, with good recommendation performance. The Google Cloud Services platform can promote teaching and research exchange activities among teachers. The use of artificial intelligence and digital tools makes teachers improve their professional skills in knowledge base, instructional design, teaching and research between 24.04% and 91.00%, and with their intervention, teacher competency shows significant improvement.

Keywords: ASTD Competency Framework, Artificial Intelligence Technology, Google Cloud Services, Teacher Professional Skills

1. Introduction

Information technology represented by artificial intelligence and big data is gradually integrated into various stages in the field of education, which not only provides more opportunities for the reform and innovation of education and teaching, but also provides the technical basis and realization conditions

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for the generation and practice of new educational concepts [1-3]. The current wisdom education teaching reform relying on intelligent information technology is in full swing, promoting the cultivation of students' core literacy, personalized development and the enhancement of teachers' teaching competence, which has become the focus of common concern in the current education and academic circles [4]. Under the background of smart education, teachers should not only be able to collaborate with humans and machines to carry out personalized, diversified and adaptive teaching, but also focus on the cultivation of students' core literacy, and the requirements for parenting will be more stringent and detailed [5-7]. In order to adapt to and promote the change of intelligent teaching, teachers' teaching ability should also be changed according to the situation, so as to realize the precise “teaching” and personalized “learning” [8-9].

The rapid development and wide application of Internet technology have accelerated the pace of knowledge updating and technological progress, and in order to further narrow the informatization gap between China and other countries and enhance China's digital competitiveness, the state attaches great importance to enhancing the digital literacy of the whole population, and at the same time, puts forward new requirements for teachers [10-12]. The term “teacher competence” can accurately and effectively describe all the characteristics and traits that a qualified teacher should have to realize successful education and teaching [13]. With the emergence of artificial intelligence and digital tools, the concepts and methods of IT education are constantly being updated, which puts higher requirements on teachers' teaching, i.e., teachers should change their roles from “leader” to “guide” [14-16]. In this regard, exploring a teaching competency framework that meets the requirements of the new curriculum reform can help guide IT teachers to further define the direction of their own professional development, and improve the quality of the curriculum and teachers' teaching ability.

A large number of scholars have conducted research for the current development of accurate teaching competence for IT teachers, aiming to improve the digital teaching ability of teachers, enhance the teaching quality of IT courses, and provide some guidance to promote the professional development of teachers. Muttaqin, I. emphasized the necessity for teachers to have informatization competence in the era of AI, pointing out that the instructional design of teachers under the digital technological support will be more convenient and greatly enriches students' learning experience, which in turn improves students' enthusiasm for learning [17]. Zhang, Y. pointed out that cultivating teachers' digital and intelligent competence is crucial to improving education quality and teaching effectiveness, and constructed a theoretical framework of teachers' intelligent competence to provide theoretical guidance and practical paths for improving teachers' digital application competence [18]. Ally, M. constructed a competency analysis framework for digital teachers based on expert advice and interview results, which developed a profile of competencies needed for the development of digital teachers, which is conducive to the preparation of future-oriented digital teachers [19]. Chen, Q. showed that the wide application of artificial intelligence technology in the field of education likewise puts forward requirements for the digital teaching ability of teacher trainees, and based on the investigation of the factors affecting their digital skills, the digital teaching ability cultivation strategy is proposed to promote the improvement of the digital teaching level of future teachers [20]. Kim, S. et al. established the Technology Pedagogical Content Knowledge (TPACK) framework, which effectively promotes AI teaching by analyzing the curriculum and resources for K-12 AI teaching and setting requirements for teacher competency [21]. Yang, W. et al. analyzed the competency needs of teachers in the K-12 robotics education industry, and established a competency model based on “professional task competency - professional knowledge skills - professional quality”, which can provide important guidance for teacher skills training [22]. Gunawan, K. D. H. et al. explored the importance of artificial intelligence technology for developing the professional competence of information science teachers, and that the use of AI technology can effectively assist teachers in developing an integrated science learning model based on higher order thinking skills [23]. Purnomo, P. et al. examined the effectiveness of a blended learning model for enhancing teachers' digital competence, which relies on a flexible and personalized learning process appealing to adult participants' interest in learning and facilitating teachers' learning of AI knowledge [24].

The study constructed a digital competency framework for teachers containing multiple factors based on the ASTD competency model, and classified digital teaching competencies into threshold competencies and professional core competencies. Then, the knowledge points are data organized and Bayesian networks are used to extract personalized learning paths that meet the teachers' professional skills improvement. Candidate resources are extracted according to teachers' knowledge level, and the most suitable learning resources are further screened through learning styles to complete the recommendation. Combined with Google cloud service digital tools, build teachers' virtual teaching and research community to realize multiple knowledge sharing and accumulation as well as online interactive lesson preparation and other teaching activities. Combine with typical cases to analyze the application effect of artificial intelligence and digital tools in teachers' professional development.

2. Pathways for professional skills enhancement based on artificial intelligence and digital tools

2.1. Recommendations for personalized learning resources for teachers

2.1.1. Recommendation model. Learners have different personalities, and the learning resources they need are also different. Learners with strong learning ability may want to learn some challenging content with high difficulty, while learners with average learning ability may prefer simpler learning resources that are easy to understand. In order to fully take into account the many aspects of learners' personality characteristics, improve the quality of resource recommendation, and ultimately enhance the learning effect. In this section, a learning resource recommendation method based on learners' personality is designed based on artificial intelligence technology, and the learning resource recommendation framework based on learners' personality is shown in Figure 1.

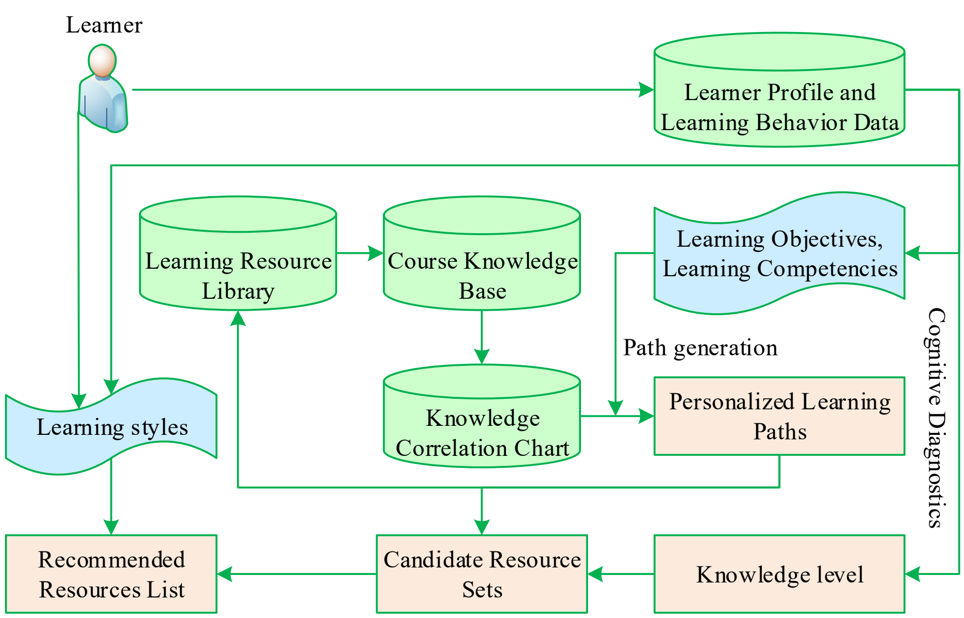

Fig. 1. Recommendation on resource based on learner personality

The specific realization process mainly includes the following steps:

1) Acquire learners' learning objectives and learning abilities based on their learning behavior data, and organize the data on the knowledge points in the learning objectives.

2) Use this obtained information as the a priori information before recommendation, and advance the personalized learning path that meets their needs from the knowledge point association graph using the method based on Bayesian network [25].

3) Use cognitive diagnostic model to further acquire the knowledge level of the learner.

4) Based on the learning path and learner's knowledge level, extract candidate resources from the learning resource library.

5) Further screen out the learning resources that are compatible with the learner based on the learning style, generate the recommended list of learning resources, and complete the recommendation.

2.1.2. Candidate resource extraction. The knowledge level of the learner determines the difficulty of the learning resources acquired by the learner, and the specific process of candidate learning resources extraction is as follows:

1) The initial knowledge level of the learner is pre-tested by the rule space model, and then the fuzzy cognitive diagnostic model is used to update the knowledge level of the learner in real time, which is used to accurately obtain the current knowledge level of the learner.

However, the learner's knowledge level will change with the learning process, including forgetting over time and changes in subsequent learning. In this paper, we utilize the fuzzy cognitive diagnosis method [26] (FuzzyCDF) to update the learner's knowledge level. FuzzyCDF can diagnose the subject's performance on subjective and objective questions at the same time in order to make up for the shortcomings of the existing cognitive diagnosis methods, and the FuzzyCDF model is shown in Figure 2. The model is a generative process starting from the latent traits of the subject, determining the subject's skill level, then calculating the subject's mastery of each test question, and finally predicting the subject's performance on each test question by taking into account the factors of error and guessing.

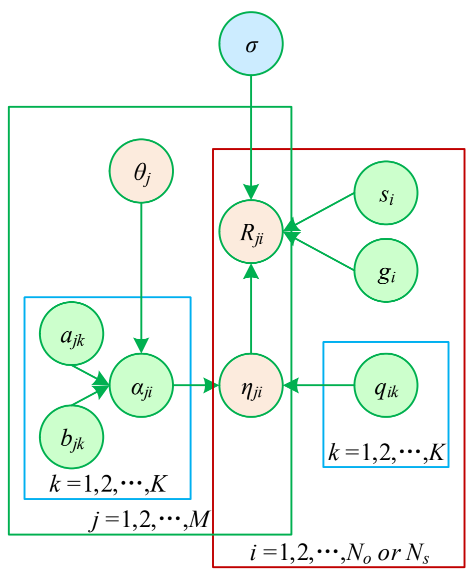

Fig. 2. FuzzyCDF model

In the figure, α_{jk} denotes the subject with latent trait θ, whose logistic Steele model is expressed as Eq. for the level of the k rd knowledge point:

$$\alpha_{jk} = \mu_k(j) = \left(1+\exp\left(-1.7a_{jk}\left(\theta_j - b_{jk}\right)\right)\right)^{-1} \tag{1}$$

a_{jk} is the differentiation of the test, and b_{jk} is the difficulty of the test. Thus, the performance of the subjects can be calculated by the following equation:

$$P\left(R_{ji}=1 \mid \eta_{ji}, s_i, g_i\right)=\left(1-s_i\right)\eta_{ji}+g_i\left(1-\eta_{ji}\right) \tag{2}$$

$$P\left(R_{ji} \mid \eta_{ji}, s_i, g_i\right)=N\left(R_{ji} \mid \left(\left(1-s_i\right)\eta_{ji}+g_i\left(1-\eta_{ji}\right)\right), \sigma^2\right) \tag{3}$$

where, R_{ji} is the score of subject j on trial question i. η_{ji} is the subject j's mastery of the test question i.

If the relationship between the knowledge points associated with the test question is of link type, the formula is as equation (4), and if the relationship between the knowledge points associated with the test question is of compensation type, the formula is as equation (5):

$$\eta_{ji}=\mu_{\cap l \le k \le K, q_k=1} k(j) \tag{4}$$

$$\eta_{ji}=\mu_{\cup l \le k \le K, q_k=1} k(j) \tag{5}$$

where s_i represents the error rate in solving the problem, g_i represents the guessing rate in solving the problem, and σ^2 is the variance after normalization in subjective questions.

2) Combined with the learner's personalized learning path, learning resources whose difficulty level is compatible with the learner's knowledge level are selected from the educational resource library to form a candidate learning resource set to be recommended.

Learning objectives specify the set of knowledge points that learners need to master within a specified time and the requirements for the degree of mastery of knowledge points. Combined with the cognitive ability of the learner, the personalized learning path is extracted from the knowledge association graph through the Bayesian network-based learning path recommendation method. According to the personalized learning path in which, in turn, suitable candidate learning resources can be extracted.

2.1.3. Screening of learning resources. The set of candidate resources to be recommended in the previous section needs to be further screened according to the learner's learning style, because the learner's learning style determines the learner's tendency to learn in a certain way and the type of learning resources, and the system can significantly improve the learning effect and increase the efficiency of learning if it can recommend learning resources that are compatible with it. Based on the learning style model proposed by Felder-Silverman, this paper defines learning style from four dimensions:

The perceptual dimension includes two types: perceptual and intuitive. Perceptual learners are good at learning and mastering factual knowledge, while intuitive learners are more good at learning and mastering theoretical knowledge. Perceptual learners have good patience, pay attention to the detail part, and like to memorize facts. Intuitive learners prefer complex things, are good at discovering patterns, can easily grasp new concepts, have strong abstract generalization and comprehension ability, and are more careless than perceptual learners.

The information input dimension mainly includes two types: visual and verbal. The former is easy to remember what they see, such as videos, images and pictures that they see. The latter are better at grasping what they hear and read.

The information processing dimension is subdivided into two style types: active and contemplative. The former prefer to acquire knowledge through active discussion, exploration, or application of explanations, and are better at teamwork. The latter prefers to think deeply, learn alone, or explore learning with a regular learning partner.

The content comprehension dimension includes both sequential and integrative types of learners. The former prefer to learn in a step-by-step manner and understand content in a strong logical order. The latter are more adept at thinking holistically and have a strong ability to diverge and think in leaps and bounds.

2.2. Digital Teaching and Research Activities under Google Cloud Services

Online teaching and research activities under Google Cloud Services [27] are centered on supporting schools and teachers' personal knowledge management, and their design revolves around schools' organizational knowledge management and teachers' personal knowledge management. The design of teaching and research activities under Google Cloud Services is divided into three major modules, which mainly include: the Google sites collaboration platform module, the Google docs file module and the Google other suite modules.

On the basis of analyzing the demand for teaching and research activities in schools, and taking into account the functions realized by Google Cloud Services, we mainly focus on the network applications of Google sites collaboration platform and Google docs files, and design teaching and research activities in the network environment with the assistance of other packages.

2.2.1. Collaboration platform module. Online teaching and research activities need to be co-managed by the school's teaching and research office and the subject teaching and research groups. The site sharing privileges in this study were set as follows: three teachers from the school's teaching and research office and the author were the site owners, the heads of each grade level and subject group were the site collaborators, and the rest of the teachers were the viewers.

The collaborative platform presents the content and resources of the teaching and research activities in the form of a website.The Google Cloud Computing Web Platform provides five types of web pages: normal web pages, facing pages, announcement pages, file box pages and list pages. The author designed the homepage of the whole collaborative platform by choosing different page templates according to the needs of the teaching and research activities. The specific activities in the homepage are shown in Figure 3.

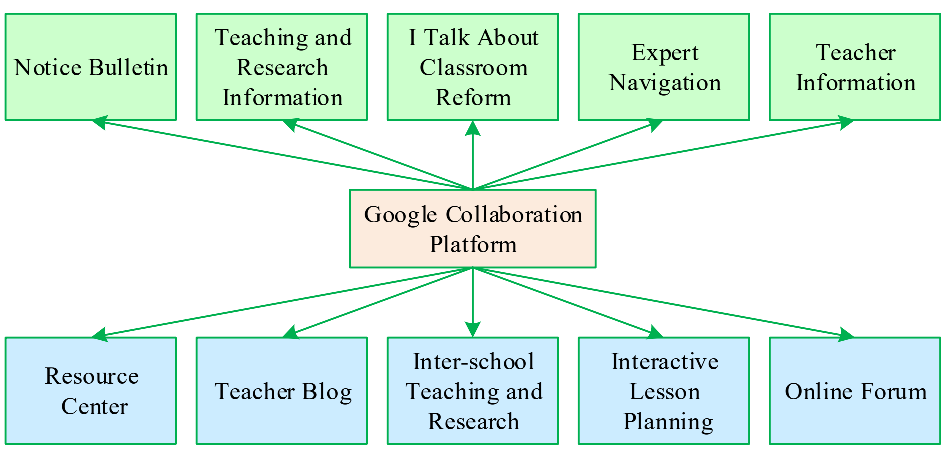

Fig. 3. Google collaboration platform activity design chart

2.2.2. Documentation module. The main function to be realized by the documentation module in this study is collaborative lesson planning. Collaborative lesson preparation centers on the process of collaborative editing on the web by subject preparation teams to research and design lesson plans or solve a particular teaching challenge.

To design a good collaborative lesson planning session, the following process needs to be followed:

1) Drafting. The initiator and organizer of the collaborative lesson preparation first sort out the teaching content, clarify the teaching objectives, establish the teaching key points and difficulties, and initially form the teaching design. Then the initiator's first draft is revised on the collaborative platform, useful suggestions are put forward, and the teaching design is constantly adjusted with the opinions of other teachers.

2) Communication. Communication takes place throughout the whole process of collaborative lesson planning. At the draft stage, the initiator can communicate with other teachers to determine the content and objectives of the lesson. During the collaborative lesson preparation, collaborators can communicate with other collaborators whenever they encounter problems or questions.

3) Forming lesson plans. In the process of collaborative lesson planning, collaborators continue to revise and gradually form an initial lesson plan. The initiator synthesizes the collective wisdom and opinions, and organizes the initial lesson plans permeated with collective wisdom to form the final lesson plans.

4) After setting the permissions, the members of the preparation group can start collaborative lesson planning.

2.2.3. Other suite modules. Other suites under the Google Cloud Computing Platform, such as Google Notebook, Google Calendar, Google Mail, etc., with their unique functions, are favorable complements to the design of virtual teaching and research activities.

For example, users are able to collect and organize text editing from the web and link to their own Google Notebook. Able to edit the text themselves for educational narratives. Can also publicize the notes and share them with others. And Google Calendar to realize the function of scheduling for the teaching and research activities, through e-mail notification to individual teachers, and design reminder function.

2.3. Analysis of Artificial Intelligence and Digital Technology Applications and Effects

2.3.1. Evaluation of Learning Resource Recommendation Model Effectiveness. In this section, a questionnaire survey is conducted to verify the effectiveness of the learning resource recommendation model based on artificial intelligence technology. The objects selected for the survey study are 50 teachers in a school in A city of a province. Teachers were first given access to the Google cloud service platform built above that integrates personalized learning resource recommendation, using each attribute of teaching resources to evaluate the function of the resources and the resource recommendation function. The platform was run and tested for a period of time, and data were collected by distributing questionnaires and filling out questionnaires to them. The questionnaire evaluates the learning resources recommendation in five dimensions: accuracy, applicability, timeliness, personalization, and diversity, with 1-4 questions for each dimension and a total of 15 questions. The questionnaire options were based on a 5-point Richter scale, with ratings from 1 to 5 to quantify the effectiveness of the recommendations, and the higher the rating, the better the effect. The survey was distributed 50 questionnaires, and 50 were effectively recovered, and the data were statistically and analytically analyzed.

The results of the questionnaire survey on the dimensions of the effectiveness of learning resources recommendation are shown in Figure 4. From the data in the figure, it can be seen that the investigators' scores in each dimension satisfy the normal distribution, i.e., there are fewer people with high or low scores, and most of them are concentrated around the average score. Specific analysis shows that the average scores of accuracy, applicability, timeliness, personalization, and diversity of learning resource recommendation are 4.544, 4.308, 4.491, 4.123, and 4.206 respectively, and the overall effectiveness of resource recommendation is good. Among them, the accuracy dimension as well as the timeliness dimension scores are relatively high, which indicates that the model recommends scientific and accurate content and can update the resource content in time to reflect the latest knowledge.

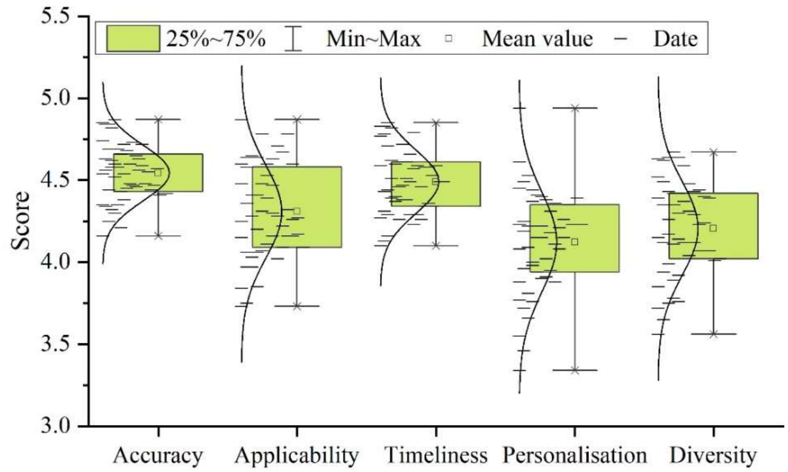

Fig. 4. Evaluation of the recommended effectiveness of learning resources

2.3.2. Measurement of the density of online interaction in teaching and research activities. In this section, social network analysis (SNA) was used to analyze the online teaching and research situation based on the Google services platform in comparison with traditional teaching and research. The teaching and research network among 10 teachers (A1~A10) of the same subject group was counted. And this paper considers that the guidance and interaction of participants in the teaching and research activities are directed, and uses this as the basis for constructing the binary value matrix and calculating the overall network density. According to the formula for calculating the density of the network of directed relationships in the overall network in social network analysis:

$$m / n(n-1) \tag{6}$$

where m denotes the number of actual relationships contained in the network and n is the number of participants.

1) Analysis of traditional teaching and research activities. Figure 5 shows the network diagram among the participants in the process of traditional teaching and research activities. It can be clearly seen from the figure that although all the teachers in the subject group participated in the teaching and research activity, the activity was mainly dominated by the task statement and division of labor by A2. The communication among teachers was mainly based on one-way passive acceptance and lacked two-way interaction. The density of this overall network is calculated to be 0.516, indicating that traditional teaching and research activities have little influence on the attitudes and behaviors of the participants in them.

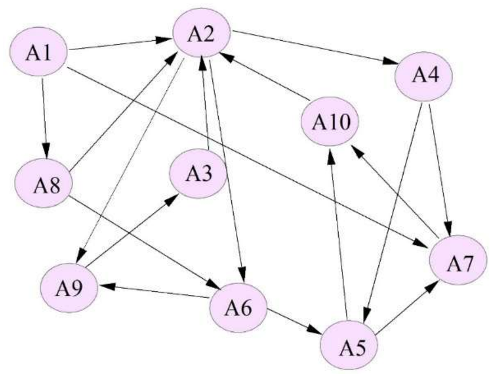

Fig. 5. A network map of participants in the traditional teaching activity

2) Analysis of teaching and research activities based on the Google service platform. Figure 6 shows the network relationship diagram of the teaching and research activities based on Google service platform. As shown in the figure, all the teachers in this subject group participated in this interactive activity, and it can be clearly seen that the network of communication and interaction between teachers became complex. After calculation, the density of this overall network is 0.835, which indicates that this network has a large influence on the attitude and behavior of the actors in it.

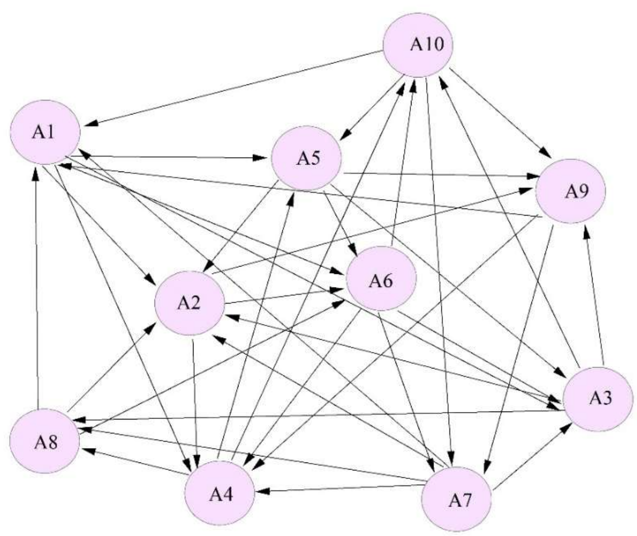

Fig. 6. A network diagram based on the Google service platform

3) Analysis of participants' activity. Since this paper mainly takes the interaction or not of the participants in the network as the value criterion when constructing the matrix, the above network diagram only portrays the instructional and interactive relationship between the participants, and does not show how active the participants are in the process of instructional interaction. In order to remedy the above shortcomings, this section analyzed and processed the processual records of the two teaching and research activities, and counted the number of times the actors spoke during the same time period. The comparison reveals that in the traditional teaching and research activity, except for A2, teacher A7 spoke more actively and interacted with other teachers in the subject group. In the teaching and research activities based on the Google service platform, teachers A1, A3, A5 and A8 were outstanding and carried out intense discussion and exchange activities, put forward more feasible suggestions and programs, and the number of speeches was higher than that of traditional teaching and research.

2.3.3. Analysis of professional skills improvement based on expert judgment. In order to objectively evaluate the enhancement of teachers' professional skills by AI and digital tools, 10 experts in related fields were invited to this section. By participating in online open class teaching, 50 teachers were evaluated and recorded the changes in their professional skills under the seven dimensions of knowledge reserve, instructional design, teaching and research, practice, communication, technology application, and reflection. After the open class teaching, the above indicators were scored on-site (out of 10), comparing the scores of teachers' professional skills before and after applying the Google service platform. Using SPSS software, an independent sample t-test was performed on the scoring data to further analyze the differences in professional skills scores before and after.

Figures 7 and 8 show the teachers' professional skill scores before and after applying Google service platform respectively, and Table 1 shows the statistical results of the professional skill score data. Combining the two figures, it can be seen that in the traditional classroom for open class teaching, the scores of each teacher on knowledge reserve, instructional design, teaching and research, practice, communication, technology application, and reflection ranged from 2.5 to 8, and the number of relatively high scores was small. In contrast, with the intervention of artificial intelligence and digital tools, the minimum and maximum scores of teachers on all dimensions were significantly higher.

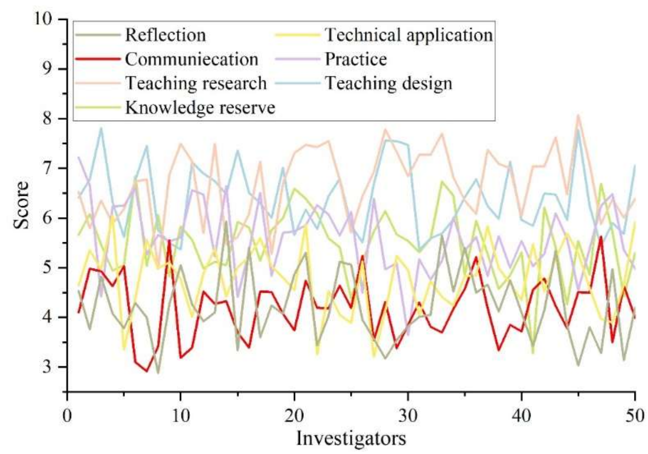

Fig. 7. The teacher professional skills score in front of the Google service platform

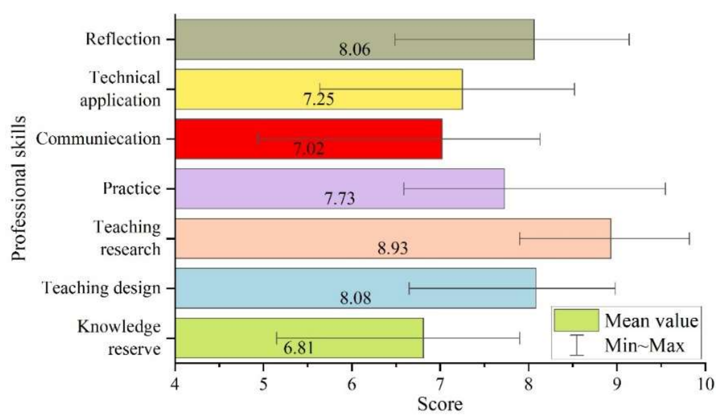

Fig. 8. The teacher professional skills score after the Google service platform

And through Table 1, it can be seen that the application of Google service platform improved the average scores of the above dimensions of the teachers, with the increase ranging from 24.04% to 91.00%, especially with the most obvious effect of the improvement of reflective ability. In addition, the significance coefficients P of each dimension are less than 0.05, which means that before and after the application of Google service platform show significant differences. Artificial intelligence and digital tools promote the exchange and sharing of teaching experience through access to quality learning resources. At the same time, online teaching and research exchanges enhance the ability to reflect on teaching behaviors, summarize lessons learned, and improve teaching methods.

Table 1. Professional skills score data statistics

Projects	Mean(Pre)	Mean(Post)	P value
Knowledge reserve	5.49	6.81	0.034
Teaching design	6.39	8.08	0.016
Teaching research	6.69	8.93	0.007
Practice	5.60	7.73	0.027
Communication	4.19	7.02	0.031
Technical application	4.77	7.56	0.041
Reflection	4.22	8.06	0.03

3. Teacher digital competency framework and evaluation dimensions

Competency model is a structured combination of knowledge, skills, attitudes, individual traits, values and other competency elements of the top performers in a specific job. Currently the more popular competency models are "iceberg model", "onion model", "ASTD competency model". This paper constructs a digital competency framework for teachers based on the ASTD competency model [28].

3.1. ASTD Competency Framework

The ASTD competency model focuses on the performance of individual business competencies under the change of environmental factors, weakens the division of roles to emphasize the interdisciplinary nature of the professional field, and divides the required competencies of the profession into general and specialized competencies.

Through literature analysis, behavioral event interviews and questionnaires, a final digital competency framework for teachers was formed as shown in Figure 9. The framework is categorized on the basis of the ASTD competency model, in which digital cognitive ability, basic knowledge and skills, and basic personality traits are the "base", which is the important support and internal drive of teachers' digital competency and belongs to the threshold competency. Digital teaching competence is constructed on the "base", relying on the comprehensive use of digital cognitive ability, basic knowledge skills and basic personality traits to show competence in teaching and learning, which is the professional core competence of teachers' digital competence.

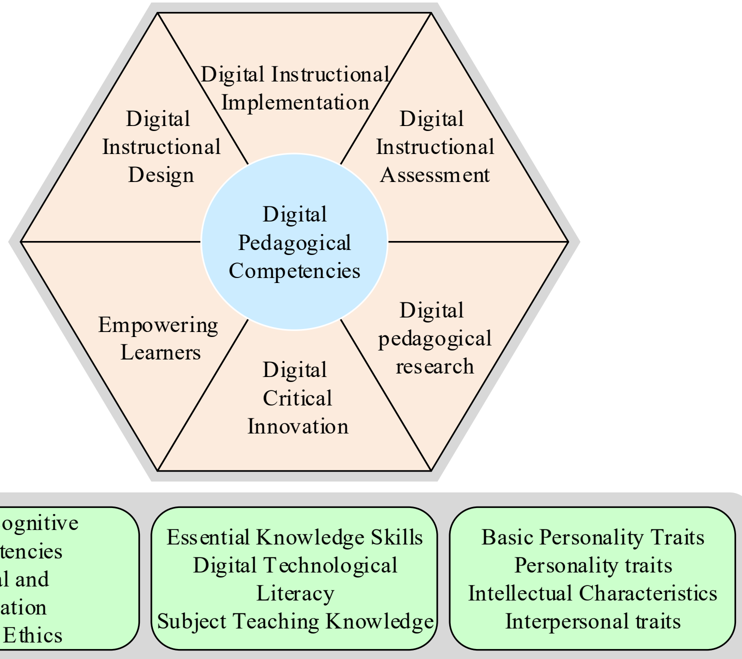

Fig. 9. The teacher's digital competence framework

3.2. Research dimensions of teaching competence

1) Digital cognitive ability. Digital cognitive competence is about teachers' awareness, attitudes and professional development awareness of the application of digital technology in education. In this framework, digital cognitive competence includes two second-level digital competency dimensions: digitalization and education, and digital ethics. Digitalization and education include "digital discipline identity", "digital discipline pursuit", and "forward-looking thinking", and digital ethics include "digital copyright awareness" and "digital privacy awareness".

2) Basic knowledge and skills. Basic knowledge and skills are the ability of teachers to effectively integrate subject knowledge with digital technology to complete teaching tasks in a digital education environment. In this framework, basic knowledge and skills include two second-level digital competency dimensions: subject teaching knowledge and digital technology literacy. Subject teaching knowledge includes "educational theory knowledge" and "subject knowledge". Digital technology literacy refers to the ability of teachers to master the basic functions of digital technology, including "digital general technology" and "digital subject technology".

3) Digital teaching ability. In the professional quality of teachers, teaching ability is the core competency of teachers' professional quality. Digital teaching competence is the ability to teach in a digital environment, which is the core dimension of this framework and the most important part of reflecting teachers' digital competency. This framework considers that digital teaching competency includes six second-level digital competency dimensions: digital teaching design, digital teaching implementation, digital teaching evaluation, digital teaching research, digital critical innovation, and empowering learners.

Digital instructional design is the starting point for teaching activities in the digital environment, including "digital goal design", "digital resource design", "digital environment design" and "digital teaching mode". The implementation of digital teaching includes five elements: "digital technology selection", "digital technology interaction", "digital monitoring and regulation", "digital teaching decision-making" and "digital personalized teaching implementation". Digital teaching evaluation refers to the use of digital technology to evaluate teachers' teaching effectiveness and students' academic performance, including "digital student evaluation" and "digital self-reflection". Digital critical innovation includes "digital critical ability" and "digital innovation ability". Empowering learners includes "facilitating learning motivation" and "facilitating learners' digital competencies".

4) Basic personality traits. In this framework, basic personality traits include personality traits, intellectual traits, and interpersonal traits. Personality traits are characterized by the traits of self-confidence, self-discipline, and flexibility. Intellectual traits include the traits of perseverance and achievement motivation. Interpersonal traits are mainly characterized by cooperation, which is manifested by supporting each other, participating in relevant activities together with others, and displaying a positive and cooperative attitude in order to achieve teaching and learning goals.

4. Case studies of teachers' smart teaching competencies

This section analyzes whether artificial intelligence and digital tools based on Google's cloud service platform show the same positive impact on teachers' competencies through typical teaching cases, using the competency framework constructed above.

4.1. Case analysis tools

This study developed the Classroom Observation Scale of Teacher Teaching Competence based on the more easily observable competence characteristics in the Teaching Competence Framework. The scale focuses on the embodiment of teachers' knowledge, the demonstration of their teaching ability, and the expression of their individual characteristics in classroom activities, in order to visually and accurately reflect the level of teachers' classroom behavior.

On the whole, the scale comprehensively covers many of the competency characteristics in the framework of teaching competency constructed above. Each indicator is scored on a 5-point scale: excellent (5 points), good (4 points), good (3 points), fair (2 points), and to be improved (1 point).

The study focuses on individual teachers through case studies, and collects information such as teachers' instructional designs and videos to examine in depth, in detail, and in a comprehensive manner their level of competence in actual classroom teaching, in order to verify the applicability of the framework in conjunction with the survey study.

4.2. Subjects of the study

This study relies on the observation and exchange activities of a school's IT quality class selection in a city in a province, A. Fifty teachers were selected as the research subjects to conduct case studies to assess their level of intelligent teaching competence in order to test the operability and applicability of the framework. 50 teachers, all of whom have bachelor's degrees, include 24 male teachers and 26 female teachers, with an average age of 30 years old, and an average of 7 years of teaching experience. The active platform was the Google Cloud Services platform used above, which provided good security conditions for this study to carry out the case study.

4.3. Research process

During the activity period from November 6 to 11, 2024, each of the four teachers had one classroom presentation opportunity, and each class was conducted in accordance with the norm of 45 minutes, with a randomly assigned classroom and all 30 students. In the process of case study analysis, consent was first sought from the teacher-researcher and the instructor, and the instructor's instructional design text and lecture video were collected in advance, with the instructional design text and lecture video being used as the research samples for the content analysis. During the quality lesson observation, the classroom teaching of each instructor was scored using the Intelligent Teaching Competency Classroom Observation Scale.

4.4. Findings

In this study, the questionnaire had a Cronbach's alpha coefficient of 0.927, indicating good reliability and high internal consistency between items. Data were collected using Questionnaire Star and statistically analyzed using SPSS. The mean values of the scores for the dimensions of competence in artificial intelligence and digital tools interference were obtained as shown in Table 2. The survey showed that the overall mean score of teachers' competency with AI and digital tools interference was 4.39. The mean values of the four dimensions of Digital Cognitive Ability, Basic Knowledge Skills, Digital Pedagogical Ability, and Basic Personality Traits were, in order, 4.42, 4.37, 4.52, and 4.26.The dimension of Basic Personality Traits had the lowest mean score of 4.26 only. The third level indicator (self-confidence) was the lowest score for this dimension at 4.11. The Digital Pedagogical Competence dimension had the highest mean score of 4.52, with most of the Level 3 indicators scoring more than 4.5. Digital cognitive ability and basic knowledge skills dimensions had similar mean scores of 4.42 and 4.37, respectively.In addition, the tertiary indicators of Artificial Intelligence and Digital Tools InterventionTechnology selection, Personalized teaching, and Digital competence had slightly higher scores of more than 4.6.

Table 2. Artificial intelligence and several word tools interfere with the mean

Dimension	Secondary index	Tertiary index	Index mean	Dimensional mean
Digital cognitive ability	Digital education	Subject identification	4.48	4.42
		Subject pursuit	4.28	
		Prospective thinking	4.33	
	Digital ethics	Copyright awareness	4.44	
		Digital privacy	4.55	
Basic knowledge skills	Subject teaching	Theoretical knowledge	4.25	4.37
		Subject knowledge	4.23	
	Digital technology literacy	Digital universal technology	4.47	
		Digital science	4.51	
Digital teaching ability	Teaching design	Target design	4.46	4.52
		Resource design	4.52	
		Environmental design	4.45	
		Teaching model	4.52	
	Teaching implementation	Technology selection	4.71	
		Technical interaction	4.49	
		Monitoring regulation	4.48	
		Teaching decision	4.56	
		Personalized teaching	4.63	
	Teaching research	Teaching research	4.44	
	Teaching evaluation	Student evaluation	4.5	
		Self-reflection	4.48	
	Critical innovation	Critical ability	4.3	
		Innovative ability	4.45	
	Enabler	Learning motivation	4.59	
		Digital competence	4.68	
Basic personality characteristics	Personality characteristics	Confidence	4.11	4.26
		Self-discipline	4.43	
		Flexibility	4.34	
	Intellectual characteristics	Perseverance	4.24	
		Achievement motive	4.18	
	Interpersonal characteristics	Cooperation	4.25	
Comprehensive score			4.39	

The independent samples t-test was used to explore the differences in teacher competence on the interference or not of artificial intelligence and digital tools. The results of the independent sample t-test of teacher competence are shown in Figure 10, from which it can be seen that the teachers with interference increased their competence in the four dimensions of digital cognitive ability, basic knowledge and skills, digital teaching ability, and basic personality traits by 19.14% to 39.94% compared with the non-interference competence. And the P-value of the significance test coefficient of each dimension is less than 0.05, which indicates that there is a significant difference between AI and digital tools interference or not making teachers' competence, i.e., AI and digital tools interference significantly improves teachers' competence.

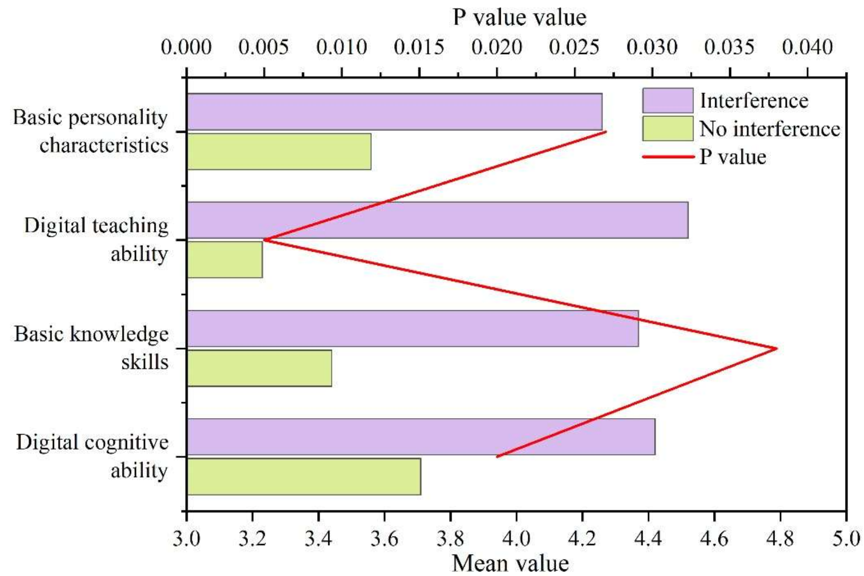

Fig. 10. Test results of independent sample t of teachers' competence

5. Conclusion

This paper integrates artificial intelligence and digital tools into teachers' professional development to enhance their teaching competence. A personalized learning resource recommendation model based on artificial intelligence algorithms is constructed to accurately acquire teachers' knowledge level using rule space model and fuzzy cognitive diagnostic model, filter the learning resource set according to teachers' styles, and generate a recommendation list. Digital tools were utilized to realize the design of digital teaching and research activities for teachers with the assistance of Google sites collaboration platform module, Google docs file module and other suite modules. The research conclusions are obtained as follows:

1) The effectiveness rating of AI learning resource recommendation is more than 4 out of 5, with the highest accuracy rating of recommendation at 4.544.

2) The network density of teachers' teaching and research under the Google cloud service platform is 0.835, while the network density of traditional teaching and research activities is only 0.516.

3) Google service platform significantly improves teachers' various professional skills, and the professional skills score increases up to 91.00%.

4) With the intervention of AI and digital tools, teachers' competency on the dimensions of digital cognitive ability and basic knowledge skills increased by 19.14% to 39.94%.

Despite the potential of AI and digital tools in enhancing teachers' professional skills, many studies remain only at the theoretical level and lack in-depth research on the application of AI and digital tools in practical teaching environments. Therefore, in the future, teachers should be encouraged to explore and apply AI and digital tools in practice, and to reflect on and improve their teaching practices through action research in order to enhance their teaching competence.

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