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PAPER

A Study of the Factors Influencing Teachers' Willingness to Use Generative Artificial Intelligence Based on the UTAUT Model

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ABSTRACT

The advancement of wireless communication and mobile computing technologies has paved the way for the extensive application of Artificial Intelligence across diverse sectors, including electronics, automotive, medical, industrial, and educational fields. Employing the Unified Theory of Acceptance and Use of Technology, this study investigates the key determinants influencing preschool teachers' willingness to utilize Generative Artificial Intelligence (GAI) in Jiangsu Province, China. The research, involving 154 participants, analyzes their inclination towards GAI adoption through four dimensions: performance expectancy, effort expectancy, social influence, and facilitating conditions. Findings reveal that performance expectancy, social influence, and facilitating conditions significantly enhance their willingness to adopt GAI. Additionally, teaching experience and IT proficiency were found to moderate the effects of certain variables on this willingness. This aligns with the broader goal of integrating digital technology into education, which is a vital element of the nexus between digital technology development and innovation.

KEYWORDS

digital technology, mobile computing, Generative Artificial Intelligence, UTAUT model

1 INTRODUCTION

The continual evolution and application of artificial intelligence, blockchain, and mobile computing herald the onset of an AI era. Particularly, mobile computing, merging computing technology with wireless communication, enables resource access and sharing, offering timely and precise information to users anytime, anywhere [1] [2]. In recent years, the application of artificial intelligence technology is gradually expanding from existing production fields to a wider range of human life [3]. The expanding scope of artificial intelligence applications, alongside maturing software and hardware technologies and reducing manufacturing

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costs, is revolutionizing traditional educational methods, potentially leading to more widespread use of educational robots [4] [5] [6]. In the milieu of 'Education Informatization 2.0' and 'Artificial Intelligence + Education', a deeper integration of machine intelligence and education is anticipated, fostering continuous educational innovation and reform.

Artificial intelligence technology constitutes a major leap in the development of information technology. One future trend in information technology education may include shifting the focus to machine learning [7]. The current process of introducing Artificial Intelligence into schools clarifies that machine learning is an important channel for introducing Artificial Intelligence into schools. As intelligent technology continues to develop, it is accelerating the digital transformation and intelligent upgrading of education, especially generative artificial intelligence (GAI) represented by ChatGPT, GPT-4, etc., which not only possesses the characteristics of GAI [8], but also can generate content through AI, making the role of AI in practice more prominent [9]. The core foundation of GAI involves the use of artificial intelligence technology in education through materialisation, humanisation, and intelligence.

In recent years, GAI has gradually entered the classrooms of students in various learning stages in various countries, and research on the use of GAI has been also increasing. Researchers have continued to discuss robot assisted education, machine learning standards, robotics teaching modes, and machine learning systems. The process of research and exploration has shifted from theoretical discussion to in-depth practical reform, and from the realisation of educational technology to the construction of educational content [10]. In China, machine learning research was accelerated in the early 21st century [4]. Primary and secondary schools across China have set up GAI courses in the form of club classes or interest classes to encourage students to sign up for various robotics competitions.

GAI drives cooperation and collaboration between humans and machines towards human-machine symbiosis. GAI can effectively coordinate human intelligence with machine intelligence, organically integrate them into a whole, and form a one plus one greater than two effect [8] [9]. GAI has also entered early childhood education. Regardless of whether machine learning can really play a role, teachers' understanding of information teaching concepts and learning of the implementation content have formed the internal factors that have restricted the development of their information teaching ability [11]; therefore, the key issue here is whether teachers can accept and use robotics-supported teaching modes [12]. Research shows that machine learning has a positive impact on the cultivation of children's knowledge, logical thinking, practical ability, and creative thinking [13]. These roles are mainly based on teachers' willingness to use GAI. However, few empirical studies have examined preschool teachers' willingness to use GAI in China. Therefore, studying preschool teachers' willingness to use GAI and how they could master its influencing factors are conducive to the development of using GAI in kindergartens. As part of a starting point for the use of GAI, it should be noted that preschool teachers play a huge role. Their willingness to use GAI could thus directly affect the effective development and promotion of the above content.

Based on this consideration, this research utilised existing relevant research results and the prototype of the Integrated Technology Acceptance Model (UTAUT), which it combined with the actual characteristics of using GAI; furthermore, it uses the questionnaire method to analyse the influencing factors of preschool teachers' willingness to use GAI and their relationships. This research has constructed a research model of and explored the internal influence mechanism underlying preschool teachers' willingness to use GAI. Furthermore, it has not only enriched and developed the empirical research on the use of GAI in the field of preschool education but also expanded the application field of the theoretical model of technology acceptance, opened up a new valve for the research on using GAI, and broadened existing research ideas regarding GAI.

2 LITERATURE REVIEW

The research on robotics education around the world began in the 1960s [10]. With the rapid development of artificial intelligence, speech recognition, bionics, and other technologies, robotics education has entered classroom teaching at various stages. Regarding the early stages of the development of robotics education, the representative ones were as follows [12] [14] [15] [16] [17]. A robot competition called 'Fire Fighting Competition' held in the United States in the 1990s laid the foundation for the development of robotics education. Later, robotics education courses were opened in high schools in the form of competitions and interest groups. In 1994, the Massachusetts Institute of Technology opened a course titled 'Design and Build LEGO Robot', aiming to improve the design and creativity of engineering design students, in an attempt to integrate robotics education with science experiments and bring American robotics education into the university classroom [15]. In Britain, robotics education is offered in primary and secondary schools. South Korea has set up a special robot high school in Seoul to cultivate new types of compound talents with communication, collaboration, problem solving, and innovation capabilities. In the 21st century, the U.S. government also issued the National Robotics Plan 2.0, pointing out the need for vigorously developing basic research on robots and encouraging other organisations, such as academia and teaching institutions, to develop robot teaching courses [12] [15]. The Singapore government has launched a new program aimed at training highly educated scientific and technological talents in various skills including robotics education and 3D printing technology. Thus, various countries have attached great importance to robotics education in primary and secondary schools and universities.

In China, the research on robotics education has been gradually strengthened. The theoretical research mainly focuses on relevant concepts, current situation, teaching mode, and curriculum system of robotics education. Peng [16] first proposed the definition of robotics education in China and discussed the basic types of robotics education. The current research situation and existing problems of robotics education were analysed, and the idea of promoting robotics education was proposed [17] [18] [19]. At the same time, the four elements of course goal, content, activity, and evaluation of robotics course design were optimised [20], and the relevant robotics education course system was actively established [21] [22]. Robotics education has also gradually received greater focus in China's educational practice, with greater focus on primary and secondary school stages and less focus on the kindergarten stage. At the beginning of the 20th century, Jingshan School in Beijing, China, incorporated robotics education into the information technology curriculum in the form of scientific research projects. Schools such as Shanghai Southwest Weiyu Middle School and Luwan High School began to explore and try to introduce robot activities into the classroom in the form of 'school-based curricula'. The State Council of China issued and implemented the Development Plan for a New Generation of Artificial Intelligence, which clearly pointed out that AI related courses should be set up in primary and secondary schools and that programming education should be gradually promoted. The Ministry of Education of China has selected Beijing, Wuhan, Guangzhou, Xi'an, and Shenzhen as the first pilot cities for AI education implementation. In China, such research on robotics education is more concentrated in primary and secondary schools and universities, while the research pool on robotics education in the early childhood education stage is relatively small.

The new generation of GAI, represented by ChatGPT, is integrating into the education field at an unprecedented speed, breadth, and depth, profoundly changing people's learning and lifestyle. At the end of 2022, ChatGPT, a large-scale language model developed by OpenAI, emerged, pushing global artificial intelligence technology to a new stage of development [23] [24]. With the increasing emergence of GAI research achievements, GAI in the early childhood education stage has attracted more researchers' attention, and the research focus has shifted from higher education to basic education and further to early childhood education [25]. However, preschool teachers' own willingness to use information technology plays a crucial role in whether it can be widely used in kindergarten education and teaching activities. In recent years, researchers have applied the technology acceptance model to the field of education. In this study, researchers have searched the Web of Science database for research literature on teachers' willingness to use information-based teaching. The search format was TS = ('Teacher information teaching acceptance'). It was found that research on teachers' willingness to use information-based teaching has been rising year by year. Thus, research on the factors influencing such acceptability has attracted increasing attention along with research on teachers' willingness to use information technology. Different theoretical models of technology acceptance have been adopted to explore teachers' technology adoption and use intention.

There are many theoretical models related to technology acceptance. At present, the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT) model are widely used in the field of education. Compared with other theoretical models, the UTAUT model has a higher degree of interpretation, with an interpretation of 70% [26]. The relevant theoretical models of technology acceptance have gradually developed and become increasingly popular in various fields. At present, there are eight major theoretical models of technology acceptance: Theory of Reasoned Action (TRA), Motivational Model (MM), Model of PC Utilisation (MPCU), Theory of Planned Behaviour (TPB), Technology Acceptance Model (TAM) C-TAM TPB, Innovation Diffusion Theory (IDT), and Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT model was developed by Venkatesh and Davis et al [27] [28] [29], who measured and tested more than 20 variables in the previous model in 2003; on this basis, they extracted four factors that mainly affect user acceptance motivation—performance expectation (PE), effort expectation (EE), social influence (SI), and facilitation conditions (FC)—as well as four regulatory variables: age, gender, experience, and voluntariness. That is, it is an integrated model of technology acceptance and use including individual and social factors [30]. Researchers can examine teachers' willingness to use information technology and the factors that affect middle school teachers' willingness to use digital environments based on the UTAUT model [31]; furthermore, the UTAUT model can be utilised for assessing preschool teachers' electronic whiteboard teaching acceptance in order to deeply understand the relevant factors that affect their willingness to use the interactive electronic whiteboard [32]. The UTAUT model as well as descriptive statistics and the structural equation model have been utilised for analysing the factors influencing K12 teachers' willingness to use e-bags [33].

Based on the UTAUT model, research on changing corresponding variables has gradually increased (including changes in regulatory variables), and a model of influencing factors related to the willingness to use information technology has been constructed. As research on 'users' willingness to use information technology based on the UTAUT model has increasingly matured, researchers have gradually tried to apply the model to different related fields (increasing or decreasing variables based on the original model for related research fields) and finally achieved success [34]. For example, in combination with the characteristics of college informatisation teaching, computer anxiety (CA) and self-efficacy (SE)—two external variables—have been introduced on the basis of the integrated technology acceptance model (UTAUT), and an influencing factors model of college teachers' informatisation teaching acceptance has been constructed [35]. Seven new constructs (interaction, self-efficacy, innovation and motivation, satisfaction, attitude, literacy, and readiness, and non-functional needs) were added to the UTAUT model to investigate the adoption of mobile learning [36]. Furthermore, regarding the change of the moderating variable in the UTAUT model, Zhang et al. [37] added teaching age as the moderating variable on the basis of the UTAUT model and conducted a study on the influencing factors of primary and secondary school teachers' use of online learning space. These previous studies have provided a certain literature basis for the construction of this study's research model and the proposition of its research hypothesis.

3 MODEL AND HYPOTHESIS

Based on the analysis of relevant research and the theoretical model of acceptability, this study uses the UTAUT model as its basic theoretical structure model. The literature review has shown that the UTAUT model was applied to research on technology adoption and used by many scholars after its proposal. Venkatesh et al.'s [28] model exceeded previous technology acceptance models (such as TAM model) in terms of usefulness and quality. The original model structure of the UTAUT model consists of four independent variables, namely performance expectation (PE), effort expectation (EE), social influence (SI) and facilitation conditions (FC), as well as four regulatory variables, including age, gender, experience, and voluntariness. That is, it is an integrated model of technology acceptance and use that includes individual and social factors. The concepts of four core variables are defined as follows: PE refers to the extent to which users believe that the application of a technology can help them achieve a better performance level; EE refers to the degree to which users perceive that a technology is easy to apply; SI refers to the influence that users perceive from surrounding people when they adopt or reject a technology; FC refers to the extent to which existing structures or conditions perceived by users can support their application of a technology.

The UTAUT model (Figure 1) is often used in the field of education, providing researchers with an effective tool to measure and predict users' behavioural intentions and behaviours towards information technology. The theoretical model mainly includes the following three values. First, it develops PE, EE, SI, and FC, the four elements that affect individual technology acceptance, on the basis of the existing theoretical model, and gives a detailed description of its core. Second, it introduces regulatory variables; this allows the model to be more explanatory and universal and also increases the perfection of the technical theoretical model. Third, because the UTAUT model has a strong degree of interpretation, it provides a unique advantage to research on user technology acceptance.

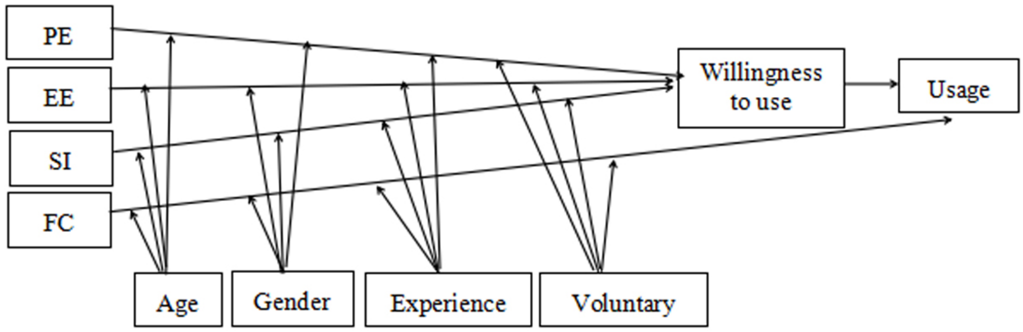

Fig. 1. Unified Theory of Acceptance and Use of Technology (UTAUT) model

Based on the UTAUT model, this current research investigates the influencing factors of preschool teachers' willingness to use GAI; it uses the four core determinants in the UTAUT model: performance expectation, effort expectation, community influence, and facilitation conditions. Considering the development of using GAI in kindergartens, the use intention and use behaviour in the original model have been collectively referred to as the acceptance degree; this has been used as the dependent variable of the model in order to reflect the use intention and use behaviour of teachers (with GAI experience) with regard to GAI. In combination with previous studies [34] and based on the UTAUT model, the adjustment variables of this study were processed as follows: the 'gender' variable was retained, the 'age' variable was deleted, and the 'teaching age' variable was added. This is mainly because the teaching age of preschool teachers can not only effectively reflect the length of their teaching time and age but also show their own teaching age experience. Since most preschool teachers do not have rich usage experiences, the 'experience' variable was deleted. The 'voluntary' variable was also deleted, and the 'Information technology proficiency' variable was added. This study also considered the fact that preschool teachers with different information technology proficiency levels may have different perceptions of FC, PP, PI, and other variables. Therefore, the moderating variables of this research model were selected as follows: gender, teaching experience, educational background, and information technology proficiency. In summary, Figure 2 shows this study's theoretical model of the factors influencing teachers' willingness to use GAI.

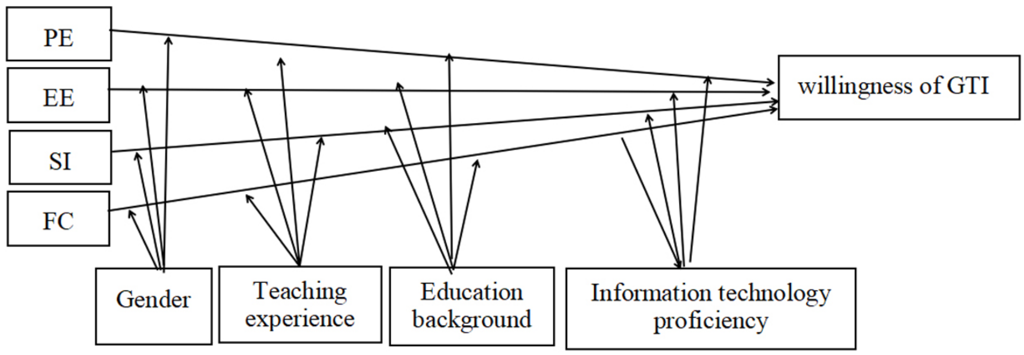

Fig. 2. The UTAUT model of preschool teachers' willingness to use GAI

Based on the theoretical model of influencing factors of preschool teachers' willingness to use GAI and the actual situation of preschool education, the research assumptions of this study were analysed as follows:

Performance Expectation (PE) indicates the extent to which kindergarten teachers believe that using GAI can improve their work performance and stimulate children's learning interest. If the introduction of GAI into preschool education and teaching activities will help promote their professional growth and stimulate children's interest in activities, teachers may be more willing to carry out GAI. The specific hypothesis is:

H1: Performance expectation has a significant positive impact on preschool teachers' willingness to use Generative Artificial Intelligence (GAI).

Effort Expectation (EE) indicates the extent to which preschool teachers believe that they need to make efforts to carry out GAI, which is related to the difficulty of conducting GAI. If the technical system related to GAI is relatively simple and easy to use, and teachers do not need to spend more time preparing lessons and teaching modules in order to successfully guide children to complete robotics projects, then teachers may be more confident and willing to carry out GAI. The specific hypothesis is:

H2: Effort expectation has a significant negative impact on preschool teachers' willingness to use Generative Artificial Intelligence (GAI).

Community Impact (SI) refers to the extent to which preschool teachers are aware of influential people's support towards their use of GAI. If the environment (atmosphere) around preschool teachers plays an active role in their use GAI, they may accept use GAI more strongly. The specific hypothesis is:

H3: Community influence has a significant positive impact on preschool teachers' willingness to use Generative Artificial Intelligence (GAI).

Facilitation Condition (FC) refers to the degree of support for use of GAI provided by organisations or technical facilities in kindergartens where the teachers work. If the school provides adequate material security and financial support, then teachers may have a stronger willingness to use GAI. The specific hypothesis is:

H4: Facilitating conditions have a significant positive impact on preschool teachers' willingness to use Generative Artificial Intelligence (GAI).

The moderating variables can affect the direction and strength of the relationship between independent variables and dependent variables. The four moderating variables in this study's research model were as follows: gender, teaching age, educational background, and information technology proficiency. The hypotheses related to these are:

H5: Gender plays a regulatory role in the relationship between independent variables and dependent variables in the model.
H6: Teaching age plays a regulatory role in the relationship between independent variables and dependent variables in the model.
H7: Education plays a regulatory role in the relationship between independent variables and dependent variables in the model.
H8: Information technology proficiency plays a regulatory role in the relationship between independent variables and dependent variables in the model.

4 METHODS

This study's adopted research model includes independent variables (performance expectation PE, effort expectation EE, social impact SI, and convenience condition FI) and dependent variables (willingness to use GAI). With reference to the relevant research scales of Davis [27], Bu [34], Zhang [37], Birch [38], and so on, and in combination with the reality of using GAI, we independently designed the measurement items of each variable. In order to ensure the reliability and validity of the questionnaire, the current researchers conducted two rounds of research. The first round of the survey randomly selected 50 kindergarten teachers; this was followed by a revision of the questionnaire according to the preliminary survey results. The final formal questionnaire included the following two components with a total of 25 items. The first part included a survey on the basic situation of preschool teachers (6 items: gender, teaching age, education background, class, area of kindergarten, and proficiency in information technology of the preschool teachers). The second part included a survey of the factors that affected teachers' willingness to use GAI (5 dimensions and 9 items: performance expectation [PE], effort expectation [EE], community influence [SI], facilitation condition [FC], willingness to use GAI). In order to ensure that preschool teachers would be able to identify the answers to the questionnaire, these measurement items were all presented in the form of 5-point Likert scales (1–5 indicating strongly disagree, disagree, neutral agree, strongly agree, respectively).

This study collected 154 valid questionnaires by using a professional questionnaire platform in order to conduct an online questionnaire survey; the utilised method was random sampling. The number of male preschool teachers was 17 (11.04%), and the number of female preschool teachers was 137 (88.96%). The teachers' experience ranges were as follows: 32 teachers (20.78%) with less than 3 years of teaching experience, 49 teachers (31.82%) with 3–5 years of teaching experience, 58 teachers (37.66%) with 6–10 years of teaching experience, and 15 teachers (9.74%) with more than 10 years of teaching experience; 26 teachers (16.88%) with a junior college degree, 125 teachers (81.17%) with an undergraduate degree, and 3 teachers (1.95%) with a graduate degree. In terms of proficiency in information technology, 46 were novices (29.87%), 95 were competent (61.69%), and 13 were proficient (8.44%).

5 RESULTS

5.1 Reliability analysis

Reliability assessment involves an examination of the reliability of the survey scale and results. In the questionnaire, the questionnaire is considered reliable only if the answers to the questions measuring the same indicators are the same or similar. Reliability test indicators include internal consistency reliability, split reliability, retest reliability, and so on. The most commonly used indicator is internal consistency reliability, which is generally measured using a Cronbach's Alpha coefficient. The reliability analysis of each potential variable is utilised in this study. It is generally believed that a Cronbach's Alpha value higher than 0.7 indicates a factor's high reliability. The Cronbach's Alpha coefficient values for all potential variables (Table 1) were more than 0.8, thus indicating that each measurement dimension had good reliability—that is, the internal consistency of each dimension in the questionnaire was good. Regarding the overall questionnaire and the Cronbach's alpha values, the coefficient also reached 0.837, thus indicating that the internal consistency of the total table was high—with a strong accuracy and reliability—and that these could be used for further analysis.

Table 1. Cronbach reliability analysis of the questionnaire

<table>
<tr><th>Variables</th><th>Number of Items</th><th>Cronbach's Alpha Coefficient</th><th>Standardized Cronbach's Alpha Coefficient</th><th>Overall Cronbach's Alpha Coefficient</th><th>Overall Standardization Cronbach's Alpha Coefficient</th></tr>
<tr><td>PE</td><td>4</td><td>0.930</td><td>0.931</td><td rowspan="5">0.808</td><td rowspan="5">0.837</td></tr>
<tr><td>EE</td><td>4</td><td>0.936</td><td>0.937</td></tr>
<tr><td>SI</td><td>3</td><td>0.940</td><td>0.940</td></tr>
<tr><td>FC</td><td>3</td><td>0.950</td><td>0.952</td></tr>
<tr><td>Willingness to use GAI</td><td>5</td><td>0.957</td><td>0.958</td></tr>
</table>

5.2 Validity analysis

Validity refers to the validity of the scale, indicating the correctness of the relevant measuring research characteristics. The evaluation of validity involves many levels, including surface validity, content validity, criterion validity, and construct validity. First, the KMO and Bartlett's tests were applied to the pretest questionnaire in order to determine whether factor analysis was conducted on the measurement scale. The KMO value is mainly used to judge whether the potential variables are related to each other. The KMO value is usually in the range of 0–1, and the more it tends towards 1, the better the validity. In general, a KMO higher than 0.8 indicates that it is very suitable for factor analysis; Bartlett's test is mainly used for judging the difference of each potential variable; its corresponding SIG value should be lower than 0.05. The results of this study were evaluated using statistical software. The results of the spherical test showed that there was a significant difference between the correlation coefficient matrix and the unit matrix and that the calculated KMO value (Table 2) was 0.863, thus indicating that the questionnaire had good validity. The variance interpretation rate values (after rotation) of the relevant factors (Table 3) were 17.840%, 18.146%, 13.708%, 14.855%, and 22.318%, respectively, and that the cumulative variance interpretation rate after rotation was 86.867% > 50%; this indicated that the information content of the research item could be extracted effectively.

Table 2. KMO and Bartlett's test analysis of the questionnaire

<table>
<tr><th colspan="3">KMO and Bartlett's Sphericity Test</th></tr>
<tr><td colspan="2">KMO</td><td>0.863</td></tr>
<tr><td rowspan="3">Bartlett's Test of Sphericity</td><td>Approximate Chi-Square</td><td>3456.678</td></tr>
<tr><td>df</td><td>171</td></tr>
<tr><td>p</td><td>0.000</td></tr>
</table>

Table 3. Factor load coefficients of the questionnaire

Name	Factor Load Factor				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
PE-1	0.890				
PE-2	0.888				
PE-3	0.886				
PE-4	0.796				
EE-1		0.910			
EE-2		0.884			
EE-3		0.883			
EE-4		0.866			
SI-1			0.876		
SI-2			0.877		
SI-3			0.810		
FC-1				0.935	
FC-2				0.956	
FC-3				0.906	
Willingness to use GAI-1					0.862
Willingness to use GAI-2					0.847
Willingness to use GAI-3					0.864
Willingness to use GAI-4					0.872
Willingness to use GAI-5					0.818
Variance interpretation rate% (after rotation)	17.840%	18.146%	13.708%	14.855%	22.318%
Cumulative variance interpretation rate% (after rotation)	17.840%	35.986%	49.694%	64.549%	86.867%

5.3 Descriptive statistics

The results showed that the scores of each variable were between 2.541–3.903, with the highest score being assigned to facilitation condition (3.903) and the lowest score being assigned to effort expectation (2.541). The standard deviation of the variables was less than 1.0, indicating that the scores of the relevant variables were densely distributed around the mean value; furthermore, the mean value was well represented, as shown in Table 4.

Table 4. The descriptive statistical analysis of the model variables

Variable	Mean	Standard Deviation
PE	3.654	0.686
EE	2.541	0.911
SI	3.734	0.766
FC	3.903	0.761
Willingness to use GAI	3.832	0.732

5.4 Structural equation model

The structural equation model can be used to establish, estimate, and test causality models. It can simultaneously process multiple dependent variables, estimate factor structures and factor relationships, estimate the fitting degree of the whole model, and allow measurement errors. Teachers' Willingness to use GAI model was constructed following the guidance of the UTAUT theoretical model. Through structural equation model (SEM) analysis, the key factors affecting preschool teachers' Willingness to use GAI were deeply explored. SEM includes five potential variables: PE, EE, SI, FC, and Willingness to use GAI, among which PE, EE, SI, and FC are independent variables, and Willingness to use GAI is a dependent variable (Figure 3).

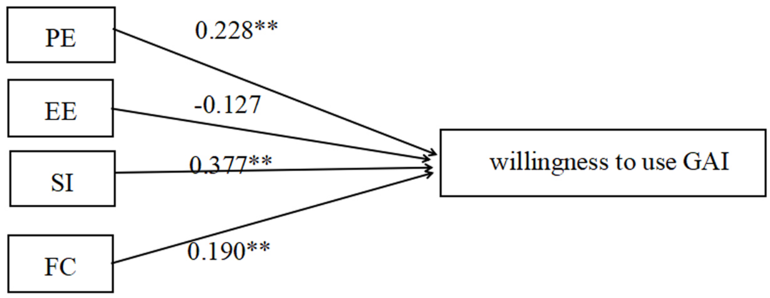

Fig. 3. The path test results of the construction model

The model structure was tested using confirmatory factor analysis. Specifically, statistical software was used for data analysis. Chi square/degree of freedom, GFI, CFI, NFI, IFI, RMSEA, and other indicators were selected to evaluate the fitting degree of the established model. Thus, the fitting degree of the structural model was found to be in an acceptable range (Table 5); this shows that the model in this study had a good fitness.

Table 5. Model fit

Common Indicators	Evaluation Criterion		Model Fit Value	Adaptation Judgment
	Acceptable	Good		
χ^2/df	<5	<2	1.858	accept
GFI	[0.7–0.9]	>0.9	0.858	accept
CFI	[0.7–0.9]	>0.9	0.965	accept
NFI	[0.7–0.9]	>0.9	0.928	accept
TLI	[0.7–0.9]	>0.9	0.958	accept
RMSEA	<0.08	<0.05	0.075	accept

Statistical software was used to test the significance of the path coefficients. Table 6 shows the path coefficients of the research hypothesis and the verification results; performance expectations ($\beta = 0.228$, $p = 0.003 < 0.01$) ($\beta = -0.127$, $p = 0.076 > 0.05$), community impact ($\beta = 0.377$, $p = 0.000 < 0.01$), and promotion condition ($\beta = 0.190$, $p = 0.004 < 0.01$) show that the performance expectation, community influence, and promotion conditions had a significant positive impact on preschool teachers' willingness to use GAI—that is, the relationship between H1, H3, and H4 in the original hypothesis test were proved. The negative effect of effort expectation on preschool teachers' willingness to use GAI was found to be not significant—that is, the hypothesis of H2 in the original hypothesis test was not established.

Table 6. Hypothesis test results in the model

Hypothesis	Route	Normalised Path Coefficient	SE	C. R. Coefficient	P Value	Hypothetical Judgement
H1	PE→Willingness to use GAI	0.228	0.077	2.933	0.003	Supported
H2	EE→Willingness to use GAI	–0.127	0.057	–1.773	0.076	Not supported
H3	SI→Willingness to use GAI	0.377	0.076	4.827	0.000	Supported
H4	FC→Willingness to use GAI	0.190	0.065	2.916	0.004	Supported

5.5 Adjustment effect test

In previous studies, Venkatesh et al. [28] and Zhang et al. [37] emphasised the importance of including regulatory variables in research on technology acceptance models. Through a comparative analysis of regulatory variables, we can find the changes in the causal relationships among variables under different conditions and the reasons for such changes; this can aid us in better understanding preschool teachers' Willingness to use GAI. In this study, gender, teaching age, education background, and information technology proficiency were the regulatory variables, and the four regulatory variables were classified data. After the dummy variable processing of the regulatory variables and the standardisation of the independent variables, the regulatory effect in the model was evaluated using the significance of the interaction. After testing, it was found that gender and education background had no regulatory effect on the relationship between the independent variables and the dependent variables—that is, the research hypotheses H5 and H7 were not established. As for the regulatory variable of teaching age, 3–5 years of teaching experience was found to have a regulatory effect on the relationship between facilitation conditions and acceptance, 6–10 years of teaching experience had a regulatory effect on the relationship between community influence and acceptance, and more than 10 years of teaching experience had a regulatory effect on the relationship between effort expectation and acceptance—that is, the research hypothesis H6 was found to be partially valid (Table 7). In terms of information technology proficiency, the competency category had a moderating effect on the relationship between performance expectation and effort expectation, which are two independent variables, and the proficiency category had a moderating effect on the relationship between performance expectation and community, which can affect the relationship between the two independent variables—that is, the research hypothesis H8 was partially validated (Table 8).

Table 7. Interaction between each category and independent variable in teaching experience

Interaction	Teaching Experience						Hypothetical Judgement
	3–5 years		6–10 Years		More than 10 Years		
	t	p	t	p	t	p	
PE	0.155	0.877	1.589	0.114	0.838	0.403	H6: Partially valid
EE	1.022	0.308	0.950	0.344	2.448	0.016	
SI	0.869	0.386	3.153	0.002	1.532	0.128	
FC	2.484	0.014	1.566	0.120	1.059	0.291	

Table 8. Interaction between each category and independent variable in IT proficiency

Interaction	IT Proficiency				Hypothetical Judgement
	Qualified		Master		
	t	p	t	p	
PE	2.110	0.037	2.843	0.005	H8: Partially valid
EE	2.354	0.020	0.743	0.458	
SI	1.621	0.107	2.464	0.015	
FC	0.125	0.901	0.967	0.335	

6 DISCUSSION AND CONCLUSION

The results of this empirical study showed that research hypotheses 1, 3 and 4 were verified, research hypotheses 6 and 8 were partially validated, and research hypotheses 2, 5 and 7 were not verified. The results showed that performance expectation, social influence, and promotion conditions had a significant positive impact on preschool teachers' willingness to use GAI, while effort expectation had no significant impact on such teachers' willingness to use GAI. Furthermore, gender and education had no regulatory effect on the relationship between their respective variables and dependent variables, while some categories of teaching age and IT proficiency had a significant regulatory effect on the relationship between some independent variables and dependent variables.

Analysis of the research results showed that performance expectations, community influence, and facilitation conditions had a significant positive impact on preschool teachers' willingness to use GAI; this finding was similar to some early research conclusions [39] [40] and also conformed to the assumptions of the original UTAUT model. To some extent, performance expectation, community influence, and facilitation conditions were found to be the main factors that affected preschool teachers' willingness to use GAI. That is, in the process of using GAI, preschool teachers can achieve a sense of achievement by increasing opportunities for promotion and improving opportunities for improving their performance pay or professional title; this, in turn, can promote their professional development. This is inconsistent with some early research conclusions [12]. At the same time, preschool teachers must be encouraged by relevant education departments and kindergarten education leaders; they must be assisted and encouraged to exchange their use GAI technology-related experiences with other teachers. Relevant education departments or kindergartens can provide financial support for using GAI, while kindergartens can provide necessary equipment resources for using GAI.

Moreover, the effect of hard expectation on teachers' willingness to use GAI has been found to be not significant; it is not affected by regulatory variables. This conclusion is inconsistent with some early research conclusions [41] [42] and also inconsistent with the original UTAUT model assumptions. Thus, effort expectation is not an important factor that affects teachers' willingness to use GAI. It may be that preschool teachers pay more attention to the teaching effect of using GAI in kindergartens but less attention to the difficulties in robotics teaching; it may also be that kindergartens have not specifically used GAI and that preschool teachers do not understand its difficulty. At the same time, the average score of effort expectation is also the lowest in descriptive statistics, which indicates that preschool teachers, expecting to use GAI technology to be easy to operate, may not want to spend too much time preparing lessons and learning information technology knowledge related to GAI use. It may also be that preschool teachers find it easier and less difficult to use GAI.

The results show that gender and education background had no moderating effect on teachers' willingness to use GAI in terms of performance expectation, effort expectation, community influence, and facilitation conditions. The variable of gender was found to have no regulatory effect; this finding is inconsistent with the assumption of the original UTAUT model. The development of information technology and the promotion of using GAI may have affected these findings. No significant differences were found in terms of gender, and preschool teachers' views were found to be similar. The education variable also had no regulatory effect, for reasons similar to gender. At the same time, some categories of teaching age and IT proficiency had a significant moderating effect on the relationship between some independent variables and dependent variables. As for the moderating variable of teaching age, teachers with 3–5 years of teaching experience had a moderating effect on the relationship between facilitation conditions and acceptance. It is possible that teachers at this stage may have started paying attention to the resources and conditions required for using GAI compared to those who had just assumed a kindergarten teaching post and so did not pay attention to the support conditions. Teachers with 6–10 years of teaching experience played a regulatory role in the relationship between community influence and degree of influence, which shows that teachers at this stage were increasingly concerned about the support of kindergarten leaders, parents, and other aspects for their own GAI use. Therefore, more than 10 years of teaching experience could play a role in adjusting the relationship between efforts and expectations. Most teachers with more than 10 years of teaching experience possessed profound education and teaching experience. However, GAI use, a new teaching mode, still posed certain challenges for them, so they tended to pay more attention to difficulties in using GAI; this, in turn, could affect their willingness to use GAI. The moderating variable of IT proficiency had not been verified in early research. It was found that competency information technology played a moderating role in the relationship between the impacts of the two independent variables—performance expectation and effort expectation—on acceptance. Teachers who were competent in information technology had a certain level of information technology use and experience. They tended to pay more attention to their own performance expectation and the impact of effort on Willingness to use GAI. Proficiency had a moderating effect on the relationship between performance expectation and community influence, with regard to the impact of the two independent variables, on the degree of acceptance. Teachers who had achieved proficiency in information technology may have ignored the difficulties in using GAI and information technology resources, as teachers with lower technical levels often do; however, they may have paid more attention to promoting their professional growth by introducing GAI into preschool education and teaching activities. In this way, they stimulated children's interest in activities and the role of the surrounding environment in their use of GAI.

As machine computing power and deep learning reach substantial levels, the accumulation of AI expertise resembles the refinement of steel in metallurgical technology, signifying the advent of emergent cognitive technologies [43]. The growing infiltration of generative AI in education has led to increased intelligence in educational practices, making learning and teaching more multimedia-driven, autonomous, and personalized. Our research underscores the pivotal role of instructors in this transformation. The eagerness of preschool teachers to engage with GAI emerges as a key factor in enhancing the efficiency and effectiveness of these technologies in education. Therefore, our results highlight the importance of integrating GAI, technological innovation, and pedagogical strategies into a unified approach for sustainable advancement in the education sector.

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