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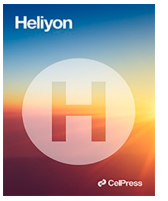

Research article

# Exploring the role of attitudes, self-efficacy, and digital competence in influencing teachers' integration of ICT: A partial least squares structural equation modeling study

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ABSTRACT

Effectively incorporating technology into teaching and learning can be accomplished through the application of information and communication technology (ICT). Nonetheless, the extent to which ICT is employed in educational environments is heavily impacted by numerous factors. Teachers' ICT integration in China was investigated with the aim of identifying the specific factors that influence it. The research sample consists of 680 educators, and it highlights three primary elements that affect their adoption of ICT: attitudes, self-efficacy, and digital competence. Employing a partial least squares structural equation modeling (PLS-SEM) method, the results indicate that all three elements play a significant role in the effective integration of ICT by educators. The study also indicated the mediating effect of attitudes and digital competence. Furthermore, the research identified no substantial disparities in the factors based on sex or age, except for the correlation between self-efficacy and attitudes. By providing useful insights for the development of successful instructional designs that integrate ICT, this study contributed to the advancement and impact of educational technology.

## 1. Introduction

Various concerns have been raised about the extensive implementation of ICT in education [1]. The existing educational system must be adaptable to change for ICT to be effectively integrated into classrooms [2]. Despite educators' growing familiarity and competence with ICT, their utilization of it remains constrained and auxiliary [3]. Many academics have demonstrated curiosity in the consequences of ICT on educational systems, particularly in emerging nations such as China [4,5]. Certain scholars have investigated the reasons behind educators' reluctance to use ICT in classrooms, while others have focused on the specific obstacles educators face when integrating ICT into their teaching [6–8]. The ICT-based teaching and learning tools and the requisite technology infrastructure have been updated to fulfill the need for ICT integration in educational institutions. This is because enhanced ICT in schools can lead to significant educational and pedagogical benefits for both teachers and students [9]. However, excessive optimism about ICT integration in education might result in some disappointments regarding overall progress [10]. Therefore, understanding the reasons behind and the effectiveness of ICT integration as a teaching tool is essential.

However, there are several difficulties in implementing information technology in education. Incorporating subjective assistance,

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interacting with students, and attaining good teaching outcomes are typically overlooked by educators when transferring classroom teaching materials to online courses. These inquiries center on ways to improve the convergence of technology and education. They include how to assist students in studying independently, how to improve instructor training, and how to successfully integrate online teaching models [11]. Even with the introduction of some rules, a small proportion of China's educators—who possess differing degrees of expertise—have not been adequately trained to use technology into their teaching practices. Students' development may be hampered if their teachers do not use technology effectively [12].

The use of ICT in education has been the subject of much research, with many studies looking at a range of contributing variables, including the attitudes, self-efficacy, and digital competence of instructors [8,13,14]. There are still not enough studies looking at the particular contextual elements that affect ICT integration among Chinese instructors, despite a lot of research being done in this area. By providing a thorough examination of these elements within China's unique cultural, educational, and technological context, this research seeks to close this knowledge gap.

Furthermore, while previous research has predominantly employed traditional statistical methods [15], Partial Least Squares Structural Equation Modeling (PLS-SEM) is used in this study to provide a more thorough knowledge of the correlations among the variables. This methodological approach allows for the examination of complex interactions and offers deeper insights into how these factors collectively influence ICT adoption.

In addition to these primary factors, the study also examines the influence of demographic variables, including gender and age, on ICT integration. These variables were chosen based on existing literature suggesting that age and gender can significantly influence technology adoption and usage patterns. For example, prior research has indicated that younger teachers may be more comfortable with technology and more inclined to incorporate it into their teaching practices compared to their older counterparts [16]. Similarly, research suggests that men instructors may have stronger self-efficacy about ICT use than their female counterparts. Gender variations in technology usage and attitudes have also been noted [17].

This study aims to provide a more thorough knowledge of the many factors impacting ICT integration by using age and gender as variables. Addressing these demographic factors is crucial for creating targeted interventions and support systems that meet the needs of different teacher groups, ultimately improving the effectiveness of ICTadoption in educational settings.

In summary, this study presents a novel angle by contextualizing the investigation within the Chinese educational system, employing advanced statistical methods, and taking into account the impact of demographic factors like age and gender. By foregrounding these aspects in the introduction, the uniqueness and relevance of this research are clearly highlighted, addressing the reader's suggestion for demonstrating the study's novelty and the need to investigate these additional variables.

Therefore, this study addresses three research questions. First, what is the relationship between teachers' attitudes, self-efficacy, digital competence, and ICT integration? Second, do teachers' gender and age affect their attitudes, self-efficacy, digital competence, and ICT integration? Third, what model can be proposed to effectively enhance ICT integration among teachers, taking into account their attitudes, self-efficacy, and digital competence?

## 2. Literature review

### 2.1. Theoretical framework

The Will-Skill-Tools (WST) model and the Technology Acceptance Model (TAM3) serve as the main theoretical foundations for this investigation. The TAM3 was developed based on four dimensions: facilitating conditions, individual differences, social influence, and system characteristics [18]. TAM 3 establishes a more detailed causal relationship between the various factors that affect individuals' inclination to adopt and utilize innovative technologies [18–20]. Therefore, the variables attitude and self-efficacy adopt from TAM3 model.

The WST model relies on three components that together can shed light on why some educators use digital tools more than others [21]. These categories are designed to investigate the connections between teachers' attitudes toward computers (will), often referred to as attitudes towards digital technologies in modern terms, teachers' technological skills (skill), and the availability of digital resources (tool). These three elements, which are crucial for successfully incorporating digital technology into classroom practice, draw attention to the model's importance and distinctiveness. For integration to be effective, there must be a sufficient technology infrastructure, positive attitudes, and talents [22]. Accordingly, the variable digital competence is derived from WST model.

For example, research by Multazam et al. (2023) examined how web-based assessments affected student learning outcomes in higher education using the WST model. Their study demonstrated that the WST model effectively facilitated the collection of large-scale data and provided insights into student engagement and performance, highlighting its utility in educational settings [23]. An further example is the research conducted by Smith and colleagues (2020), whereby the WST model was utilized to assess the efficacy of virtual teacher professional development initiatives. Their findings indicated that the WST model not only supported efficient data collection but also enabled detailed analysis of teacher attitudes and competencies related to technology integration [24].

By including these examples, this study will build on the established applications of the WST model and TAM3, thereby enhancing the theoretical framework and providing a solid foundation for understanding the dynamics of technology adoption among educators.

#### 2.1.1. Attitude toward ICT integration

ICT in education encompasses the use of computers, the Internet, and related technologies to facilitate teaching and learning. This includes utilizing software applications, digital tools, and online resources to convey knowledge, enhance educational quality, and offer richer, more interactive learning experiences. The goal of integrating ICTinto education is to provide a more dynamic, adaptable,

and varied learning environment that will support students' general growth and acquisition of information. By integrating technology, educators can better address the needs of students and instruction, as well as adapt to evolving learning environments.

The attitude of an individual is defined as their level of preference for using ICT and their perception of its effectiveness [25]. According to the latest study results, ICT offers numerous ways for students to learn and allows teachers to employ various teaching methods. Technological advancements have enabled teachers to become proficient with technology. It is essential for educators to maintain a positive attitude while using it innovatively and effectively [26]. Meanwhile, teachers' attitudes regarding utilizing digital technology in the classroom are closely correlated with their level of technological competency [27]. For instance, a research by Clipa et al. (2023) found a strong positive link between the usage of technology in classrooms and teachers' opinions about it ($r = 0.45$, $p < 0.01$) [28].

Attitudes are also one of the most influential elements influencing digital competence [29,30]. The authors of these studies link attitudes to self-directed learning and ICT integration in the classroom. Similarly, another study reveals a correlation between teachers' positive attitudes towards using technology in the classroom and their proficiency with both hardware and software [31]. It is important to emphasize the role that technology plays in education and the significance of motivation in digital contexts. Recognizing the advantages of ICT integration in the classroom is also crucial [32].

The TAM approach examines how subjective norms affect instructors' perceptions, attitudes, and behavioral intentions to utilize technology. It was discovered that attitudes about using computers were the best indicators of behavioral intention [33]. Furthermore, it found that teachers' attitudes and abilities greatly impact how they use ICT [34]. Moreover, instructors' views significantly impacted the use of ICT [35]. Therefore, it's critical to provide teachers the tools they need—infrastructure, in-service training, and refresher courses—in order to support and inspire them and change their views regarding ICT.

#### *2.1.2. Self-efficacy and ICT integration*

Researchers in education who use Bandura's self-efficacy model concur that instructors' self-efficacy ought to represent their assurance in incorporating ICT into their lesson plans [17].According to a research by Paetsch et al. (2023), educators who felt highly confident in their ability to use technology were more likely to integrate it into their lesson plans. A reported correlation value of 0.52 ($p < 0.01$) between self-efficacy and technological integration was shown to be a strong predictor of the latter [36]. The study found that attitudes and self-efficacy have a high correlation and that both are positively correlated with ICT integration [37]. Additionally, attitudes are greatly influenced by perceived self-efficacy in ICT usage, which is the strongest predictor of ICT-based activity consumption [38].

Meanwhile, teachers' ICT usage and digital competency may be impacted by their sense of self-efficacy [7]. Self-efficacy in using ICT moderated the relationship between instructors' ICT experience and their ability to develop digital competence. Individuals who are self-assured about their ability to use ICT are more capable of acquiring digital competence [39]. Similarly, educators' propensity for lifelong learning is influenced by their professional abilities and self-efficacy in incorporating technology [40]. When it comes to utilizing ICT, older teachers are more likely to be self-efficacious than younger ones [17]. Teachers have low self-efficacy attitudes about their online teaching, and many do not feel competent or have the perceived potential to educate by utilizing sophisticated technology in classrooms [41].

As a result, increasing teachers' self-efficacy could significantly increase their ICT integration.

#### *2.1.3. Digital competence*

Another important component of ICT integration in education is teachers' digital competency. ICT competency has been measured using a number of well-established frameworks in recent years, which have introduced words like ICT literacy, digital literacy, and ICT proficiency [42]. The phrase "ICT competency" is most frequently used to refer to using digital technology. The efficient use of digital knowledge, abilities, and attitudes is known as digital competence [43].

The introduction of COVID-19 and its profound effects on the field of education have brought online learning and instructors' digital competency to a whole new level. It has been confirmed that digital competence greatly influences ICT integration [44], and the more digitally proficient the instructor, the more frequently ICT is utilized [45]. Furthermore, there was a favorable relationship between the quantity of educational tools instructors used in the classroom and their degree of digital competency [46]. Liu's (2023) study, for instance, focused on user involvement on e-learning platforms and highlighted how computer-based mind mapping might enhance students' learning outcomes, cognitive presence, and reflection in online courses. This study found that interactive tools not only significantly contributed to higher levels of engagement but also improved students' digital competence by requiring them to utilize and navigate various digital tools effectively [47]. Additionally, Liu (2023) studied computer-supported collaborative idea mapping and found that students' views of cooperation had a favorable impact on their understanding of the material, their behavior, and their digital competency. This study emphasized that the use of collaborative tools fostered an engaging and interactive learning environment, which in turn enhanced students' abilities to use digital technologies competently [48].

#### *2.1.4. Gender and age with ICT integration*

Teachers' opinions on incorporating ICT into classrooms are influenced by a number of characteristics, such as age and gender, among others [49,50]. There appears to be a relationship between a teacher's age and how they feel about using ICT in the classroom [51], applicable to both male and female instructors [52]. When it comes to utilizing ICT in the classroom, novice instructors were found to be more upbeat than their more seasoned colleagues [53]. However, several studies [54,55] have concluded that no evidence of a substantial variation in ICT use and viewpoints according to the age and gender of instructors.

Meanwhile, research has shown that during ICT integration, instructors' age, gender, or self-efficacy are all the same [6,41]. But

some researchers [17,40] have reported contradictory findings.

Additionally, there are fewer studies examining the relationship between digital competence, gender, and age [56,57]. According to research, younger instructors are more digitally competent than their older colleagues, and women are often less proficient than men in this area [46]. On the other hand, some contend that age and gender have little bearing on digital competency [11].

### 2.2. Hypothesis development

The studies mentioned above lead to the following hypotheses.

**H1a**. Attitudes have a direct and substantial impact on digital competence during teachers' ICT integration.

**H1b**. The influence of attitudes on digital competence differs significantly between male and female.

**H1c**. The influence of attitudes on digital competence differs significantly between the teachers aged ≤35 years old and ≥36 years old.

**H2a**. Attitudes have a direct and substantial impact on teachers' ICT integration.

**H2b**. The influence of attitudes on teachers' ICT integration differs significantly between male and female.

**H2c**. The influence of attitudes on teachers' ICT integration differs significantly between teachers aged ≤35 years old and ≥36 years old.

**H3**. Attitudes have an indirect and substantial impact on teachers' ICT integration through digital competence.

**H4a**. Self-efficacy has a direct and substantial impact on attitudes during teachers' ICT integration.

**H4b**. The influence of self-efficacy on attitudes differs significantly between male and female.

**H4c**. The influence of self-efficacy on attitudes differs significantly between the teachers aged ≤35 years old and ≥36 years old.

**H5a**. Self-efficacy has a direct and substantial impact on digital competence during teachers' ICT integration.

**H5b**. The influence of self-efficacy on digital competence differs significantly between male and female.

**H5c**. The influence of self-efficacy on digital competence differs significantly between the teachers aged ≤35 years old and ≥36 years old.

**H6a**. Self-efficacy has a direct and substantial impact on teachers' ICT integration.

**H6b**. The influence of self-efficacy on teachers' ICT integration differs significantly between male and female.

**H6c**. The influence of self-efficacy on teachers' ICT integration differs significantly between teachers aged ≤35 years old and ≥36 years old.

**H7**. Self-efficacy has an indirect and substantial impact on teachers' ICT integration through attitudes.

**H8**. Self-efficacy has an indirect and substantial impact on teachers' ICT integration through digital competence.

**H9a**. Digital competence has an indirect and substantial impact on teachers' ICT integration.

**H9b**. The influence of digital competence on teachers' ICT integration differs significantly between male and female.

**H9c**. The influence of digital competence on teachers' ICT integration differs significantly between teachers aged ≤35 years old and ≥36 years old.

In this study, hypotheses were formulated based on a thorough review of existing literature. The nomination of alternative hypotheses was guided by empirical findings and theoretical frameworks relevant to the factors influencing ICT integration among teachers. While some hypotheses are directly supported by specific studies, others are derived from broader theoretical insights or indirect evidence.

Several hypotheses in this study are strongly supported by previous research. For example, the hypothesis that teachers' attitudes towards technology positively influence their ICT integration is well-documented in studies such as Clipa et al.(2023), which discovered a strong positive link between these factors [28]. Similarly, the hypothesis that self-efficacy affects technology adoption is supported by Pedaste et al. (2023), who highlighted how important self-efficacy is to the integration of technology [58].

Other hypotheses, while not directly supported by a specific study, are grounded in established theoretical frameworks. For instance, the hypothesis that digital competence influences ICT integration is derived from WST model and its focus on how crucial digital skills are to making efficient use of technology. The hypothesis that demographic factors such as age and gender impact ICTintegration is supported by broader sociological and educational research indicating that these variables can affect technology use and adoption patterns [59].

For hypotheses that may appear less directly supported, additional literature and theoretical perspectives provide a rationale for their inclusion. For example, while specific empirical studies on how gender affects ICT integration among Chinese teachers may be limited, general findings from studies on gender differences in technology adoption support the hypothesis that gender can play a role

in ICT integration [40].

To ensure a robust foundation for all hypotheses, a comprehensive literature review was conducted. This review synthesized findings from various studies and theoretical frameworks, ensuring that each hypothesis is rooted in a well-established body of knowledge. Where direct empirical support was lacking, theoretical insights and related empirical findings were used to justify the hypotheses.

By clearly articulating the theoretical and empirical basis for each hypothesis, this study demonstrates that all hypotheses, including alternative hypotheses, are well-supported by the literature. This approach not only strengthens the credibility of the hypotheses but also underscores the rigorous methodological approach underpinning the research.

Fig. 1 shows the comprehensive recommended structure for this project, which is based on the previously described literature review. This study will address two primary questions.

**RQ1**. What is the relationship between teachers' attitudes, self-efficacy, digital competence, and ICT integration?

**RQ2**. Do teachers' gender and age affect their ICT attitudes, self-efficacy, digital competence, and ICT integration?

**RQ3**. What model can be proposed to effectively enhance ICT integration among teachers in Henan Province, considering their attitudes, self-efficacy, and digital competence?

## 3. Methodology

This study uses a PLS-SEM technique to investigate the factors influencing teachers' ICT integration, with an emphasis on attitudes, self-efficacy, and digital competence. The use of ICT in schools is being influenced by rapid technology breakthroughs and pedagogical changes in China, which is the focus of the research. This research intends to offer insights that are especially pertinent to China's distinct educational, cultural, and technological environment by analyzing these elements within the Chinese context.

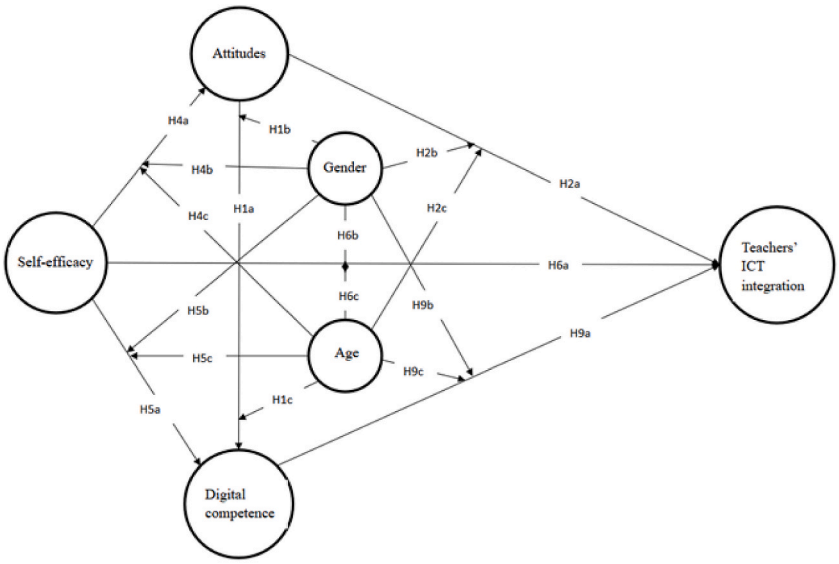
Researchers use the Smart PLS 3.3.3 algorithm in conjunction with a 5000 sub-sample resampling approach in this investigation. This method is applied to assess the model's measurement and structural design. This technique is called PLS-SEM [60]. PLS-SEM is an approach that explains how latent or hidden variables are related. A latent variable is any dormant, unnoticed, or concealed determinant that contributes to the relationship between the variables under evaluation. PLS can be used to improve latent variables by both using them and determining measurement errors.

PLS-SEM was used in conjunction with the SmartPLS program to evaluate the survey data. PLS-SEM is a potent statistical method that makes it possible to analyze intricate connections between latent and observable variables. Among the primary statistical techniques were:

Descriptive Statistics: These were calculated to summarize the demographic characteristics and survey responses.

Reliability and Validity Analysis: The composite reliability and Cronbach's alpha were employed to assess the survey scales' internal consistency. Average Variance Extracted (AVE) was used to evaluate convergent validity, and cross-loadings and the Fornell-Larcker criterion were used to estimate discriminant validity.

Measurement Model Assessment: The measurement model was evaluated to ensure that the constructs were measured accurately




H3: Attitudes>Digital competence>Teachers' ICT integration; H7: Self-efficacy> Attitudes>Teachers' ICT integration; H8: Self-efficacy> Digital competence> Teachers' ICT integration.

**Fig. 1.** The proposed framework of factors influencing teachers' ICT integration.

and consistently. This involved examining factor loadings, reliability, and validity metrics. Items with loadings below 0.70 were considered for removal to improve the model fit.

Structural Model Assessment: To investigate the connections between teachers' attitudes toward technology, self-efficacy, digital competence, and technology adoption, the structural model was evaluated. We computed path coefficients and used bootstrapping approaches with 5000 resamples to assess their significance. The paths' degrees of statistical significance are indicated by the notation "$p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$"; a p-value of less than 0.01 is regarded as highly significant, less than 0.05 as significant, and less than 0.10 as marginally significant.

Exploratory Factor Analysis (EFA): An initial EFA was conducted in order to identify the underlying factor structure of the survey questions pertaining to attitudes, self-efficacy, and digital competence, even though PLS-SEM was the principal analytical tool. This analysis ensured that the constructs were accurately measured.

The methodology section gives a thorough overview of the procedures involved in this study by including thorough descriptions of the research instrument and the PLS-SEM analytic methods employed. This level of detail ensures transparency and allows for the replication of the research.

### *3.1. Sampling and data collections*

Teachers in the Henan Province of China made up the study's sample. While there is debate about China's classification as a developing nation due to its rapid economic growth, significant regional disparities remain. Henan, one of the most populous and resource-rich regions, presents unique challenges and opportunities for ICT integration in education [61]. Despite China's overall progress, Henan faces economic and educational disparities, making it a representative case for studying ICT integration in regions with limited resources. Henan's large teacher population provides a robust sample for examining ICT practices, and the challenges they face are similar to those in other developing regions globally [62]. The Chinese government's initiatives to promote ICT in education, especially in underdeveloped areas, make Henan an ideal location to assess policy effectiveness. Moreover, Henan's strategic importance in national development plans highlights the significance of studying ICT integration in this province. By focusing on Henan, the study aims to offer insights into ICT integration in a region that exemplifies both progress and challenges in educational development, providing valuable findings applicable to other similar contexts.

The probability sampling approach known as snowball sampling was used to choose the sample. While it is true that teachers are not a hidden population and can be identified through formal inquiries and verifications, snowball sampling was used to ensure that the participants selected were highly relevant to the research objectives. By leveraging the professional networks of initial participants, the study aimed to identify teachers who are particularly experienced with ICT integration, thus providing richer and more targeted insights. In addition, snowball sampling can be more efficient and practical in certain contexts [63]. Given the constraints of time and resources, this method allowed for a quicker identification and recruitment process. Initial participants, who are familiar with the study's requirements, were able to recommend colleagues who met the criteria, hence making the process of gathering data easier. Finally, this approach made it easier to gather detailed information from participants who are knowledgeable about ICT integration techniques. Teachers who are actively engaged with ICT are likely to recommend other similarly engaged colleagues, ensuring that the sample is composed of individuals with relevant experience and knowledge.

Therefore, the non-probability sampling technique known as "snowball sampling" was employed in this investigation due to the necessity for thorough, pertinent, and efficient data [63]. The approach was carefully considered to ensure that the sample, though not random, provided meaningful and valuable insights into ICT integration among teachers. This explanation addresses the reader's concern and clarifies the methodological choice made in the study.

The researchers made contact with twenty in-service teachers from different public elementary and secondary schools in Henan Province to help with data collecting. It was required of each of these educators to collect information from no less than thirty-five other in-service teachers. The survey was available from December 20, 22 until January 20, 2023, a period of four weeks. Six hundred and eighty-eight samples of the 700 questionnaires that were disseminated online were successfully gathered. In addition to providing their informed consent, participants also supplied demographic data, including age and gender. The study's ethical guidelines were closely followed in order to protect the anonymity of the data supplied.

The sample represents the total number of responses received via the online platform. The data was reduced to 680 useable responses after outliers and missing values were removed. Table 1 displays the demographics of this study's participants, which show that out of 680 replies, 207 are male teachers and 473 are female teachers, accounting for 30.4 % and 69.6 % of the sample, respectively. Furthermore, most instructors are older than 36 years old, accounting for 63 percent of all respondents, while 37 percent

**Table 1**
Demographic information of the sample.

| Variables | Number | Percent (%) |
|---|---|---|
| **Gender** | | |
| Male | 207 | 30.4 |
| Female | 473 | 69.6 |
| **Age** | | |
| ≤35 | 252 | 37.0 |
| ≥36 | 428 | 63.0 |

are younger than or equal to 35 years old. In China, the age range for young teachers is generally from 22 to 35 years old, while the age range for middle-aged and senior teachers is typically from 36 to 55 years old. The retirement age for teachers in China is 55. Therefore, this research uses 35 years old as the dividing line to classify teachers into the categories of young and middle-aged/senior teachers (Zhou et al., 2020).

#### 3.1.1. Research instrument

The questionnaire employed in this study had been previously used in similar research and was validated through pilot testing and expert review [64–67]. It utilizes a 5-point Likert scale (ranging from "strongly disagree" to "strongly agree") and consists of 20 items across four categories: attitude (AT), self-efficacy (SE), digital competence (DC), and teachers' ICT integration (TICTI). Table 2 outlines the construction code and the total number of indicators. Fig. 2 illustrates the test model for the factors influencing teachers' ICT integration.

The pilot test involved a sample of 30 teachers from various educational institutions in China. Its purpose was to evaluate the clarity, relevance, and comprehensiveness of the survey items. Feedback from participants was used to make minor adjustments to the wording and format of the questions.

Content validity was ensured through expert review. The survey items were examined by three specialists in the field of educational technology to determine its applicability and level of representativeness for the constructs under study. Their feedback confirmed that the items adequately covered the domains of attitudes towards technology, self-efficacy, and digital competence.

Using the results of the pilot test, exploratory factor analysis (EFA) was used to assess construct validity. The calculation of the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy was done to make sure factor analysis was appropriate. The KMO value obtained was 0.86, which indicates a high level of adequacy for factor analysis (values between 0.80 and 0.89 are considered meritorious) [68]. This result suggests that the correlations between items are sufficiently large for factor analysis. According to the EFA results, the items aligned with the theoretical constructs and loaded adequately into their corresponding factors. Items with factor loadings below 0.70 were considered for removal to improve the model fit.

Through employing Cronbach's alpha, the reliability of the instrument was evaluated. The pilot test results displayed the following dependability scores: Cronbach's alpha values for attitudes, self-efficacy, and digital competence were 0.85, 0.82, and 0.88, respectively. These scores indicate good internal consistency for each of the constructs measured [68].

By detailing the validation and reliability testing, the study ensures transparency and rigor in utilizing the research instrument. The pilot test confirmed that the instrument was both valid and reliable for measuring the intended constructs within the context of this study.

## 4. Results

After determining the sample's characteristics, the proposed measurement model was subsequently analyzed to test the hypotheses. Initially, the reliability of the measurement scale was examined. Secondly, researchers analyzed the model-predicted relationships between the variables to determine whether they were in fact related. Ultimately, a multi-group analysis was performed to ascertain whether demographic variables like age and gender moderated the relationships between the dimensions.

### 4.1. Measurement model

RQ1 states that while PLS-SEM is non-parametric and does not need normally distributed data, being aware of the distribution of the data can aid in the interpretation of results and the identification of potential drawbacks.

Table 3 illustrates that the p-values of the Shapiro-Wilk and Kolmogorov-Smirnov tests are larger than 0.05 for the variables ICTI, AT, SE, and DC. This suggests that the null hypothesis, which states that the distribution of the data is normal, cannot be disproved. Consequently, it can be concluded that the data for these four variables is normally distributed.

Based on the collinearity statistics provided in Table 4, there is no significant multicollinearity among the independent variables (AT, SE, and DC) in relation to the dependent variable ICTI. Since every tolerance value is greater than 0.1 and every VIF value is less than 10, multicollinearity is not a problem in this model. This suggests that the independent variables can be reliably used in the regression analysis without the risk of inflated standard errors.

To figure out how reliable each item is, we use either standardized loading or simple correlation. A threshold of 0.55 must be met by the items' Cronbach's alpha for them to be considered reliable [60]. Thus, it can be inferred from Table 3 that all the items are trustworthy and satisfy the predetermined criteria.

PLS-SEM considers AVE, composite reliability, and Cronbach's alpha to assess convergent validity. Convergent validity at the

**Table 2**
Constructs, number of indicators, and indicators.

| Construct (Code) | No. of indicators | Indicators | Adopted and modified from |
|---|---|---|---|
| Attitudes (AT) | 5 | AT1 AT2 AT3 AT4 AT5 | [64] |
| Self-efficacy (SE) | 5 | SE1 SE2 SE3 SE4 SE5 | [65] |
| Digital competence (DC) | 5 | DC1 DC2 DC3 DC4 DC5 | [66] |
| Teachers' ICT integration (TICTI) | 5 | TICTI1 TICTI2 TICTI3 TICTI4 TICTI5 | [67] |

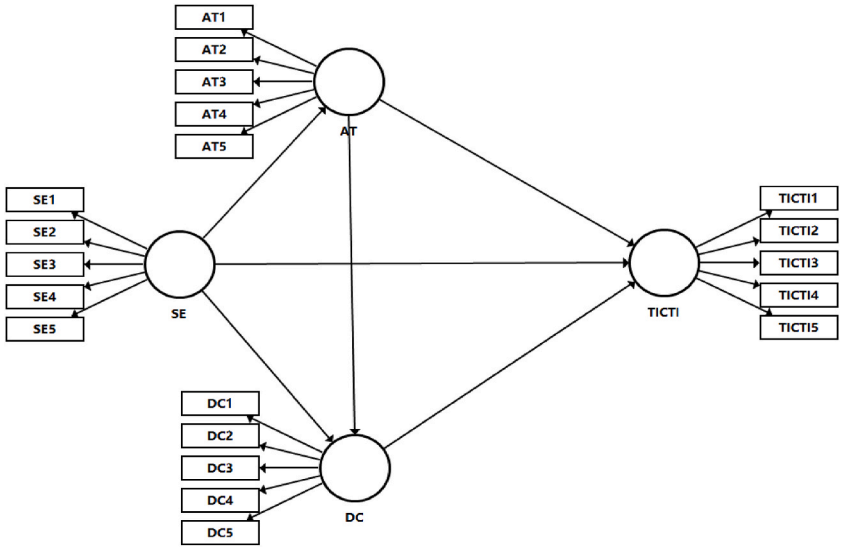



**Fig. 2.** The factors influencing teachers' ICT integration test Model.

**Table 3**
Test of normality.

| | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| ICTI | 0.209 | 680 | 0.062 | 0.868 | 680 | 0.054 |
| AT | 0.176 | 680 | 0.056 | 0.896 | 680 | 0.063 |
| SE | 0.146 | 680 | 0.072 | 0.928 | 680 | 0.081 |
| DC | 0.17 | 680 | 0.067 | 0.907 | 680 | 0.076 |

**Table 4**
Collinearity statistics.

| | Tolerance | VIF |
|---|---|---|
| (Constant) | | |
| AT | 0.559 | 1.787 |
| SE | 0.717 | 1.394 |
| DC | 0.603 | 1.659 |

a Dependent Variable: ICTI.

construct level is frequently evaluated using AVE. The construct-related indicators' squared loadings' grand mean value, or the total of the loadings divided by the number of indicators, is what determines this statistic. Consequently, AVE is the same as the communality of the construct. When an indicator's AVE value is 0.5 or higher, a construct is considered to account for, on average, more than half of its indicators' variance. On the other hand, an AVE of less than 0.5 suggests that generally speaking, there is more error in the items than the constructions can explain [60].

All of the variables meet the first condition for dependability because, as Table 5 demonstrates, their Cronbach's alpha values are all above.55. The variables also satisfy this requirement as the combined reliability of all of the variables is higher than the benchmark value of 0.7 that has been set. AVE is greater than 0.5, which is the last requirement that the variables meet [60]. As a result, the variables' convergent validity is established.

The HTMT, cross-loading, and the square root of the AVE (Fornell-Larcker criteria) are the three parameters taken into account when assessing discriminant validity [60]. The current study satisfies the first requirement for discriminant validity, as indicated by Table 6, which is that the square root of AVE (diagonal value) for each construct in the correlation matrix must be higher than the correlations between the latent constructs.

Each item's loading should be higher than the loading of the variable it is linked with, and there should be a difference between the cross-loadings that is more than zero [60]. This is the second condition for discriminant validity. As a result, it can be concluded from Table 7 that the second requirement has also been satisfied.

A value of less than 0.85 for the HTMT is the third requirement for proving discriminant validity [60]. Table 8 demonstrates that the variables also satisfy this criterion, demonstrating that discriminant validity is also established. By measuring the amount of variation

**Table 5**
Measurement model result.

| Constructs | Items | Loadings | Cronbach's α | Constructs | Average Variance Extracted |
|---|---|---|---|---|---|
| Attitudes | AT1 | 0.839 | 0.9 | 0.926 | 0.714 |
| | AT2 | 0.862 | | | |
| | AT3 | 0.837 | | | |
| | AT4 | 0.846 | | | |
| | AT5 | 0.841 | | | |
| Self-efficacy | SE1 | 0.815 | 0.862 | 0.9 | 0.644 |
| | SE2 | 0.809 | | | |
| | SE3 | 0.807 | | | |
| | SE4 | 0.781 | | | |
| | SE5 | 0.800 | | | |
| Digital competence | DC1 | 0.824 | 0.864 | 0.902 | 0.647 |
| | DC2 | 0.807 | | | |
| | DC3 | 0.818 | | | |
| | DC4 | 0.786 | | | |
| | DC5 | 0.786 | | | |
| Teachers' ICT integration | TICTI1 | 0.744 | 0.823 | 0.876 | 0.586 |
| | TICTI2 | 0.717 | | | |
| | TICTI3 | 0.783 | | | |
| | TICTI4 | 0.780 | | | |
| | TICTI5 | 0.801 | | | |

**Table 6**
Fornell-Lacker criterion.

| | AT | DC | SE | TICTI |
|---|---|---|---|---|
| AT | 0.845 | | | |
| DC | 0.619 | 0.805 | | |
| SE | 0.534 | 0.492 | 0.802 | |
| TICTI | 0.661 | 0.624 | 0.574 | 0.766 |

**Table 7**
Cross loadings.

| | AT | DC | SE | TICTI |
|---|---|---|---|---|
| AT1 | **0.839** | 0.517 | 0.456 | 0.557 |
| AT2 | **0.862** | 0.544 | 0.432 | 0.566 |
| AT3 | **0.837** | 0.528 | 0.434 | 0.542 |
| AT4 | **0.846** | 0.521 | 0.477 | 0.562 |
| AT5 | **0.841** | 0.507 | 0.456 | 0.566 |
| DC1 | 0.507 | **0.824** | 0.391 | 0.515 |
| DC2 | 0.488 | **0.807** | 0.381 | 0.521 |
| DC3 | 0.505 | **0.818** | 0.398 | 0.473 |
| DC4 | 0.498 | **0.786** | 0.415 | 0.523 |
| DC5 | 0.493 | **0.786** | 0.392 | 0.474 |
| SE1 | 0.430 | 0.418 | **0.815** | 0.479 |
| SE2 | 0.441 | 0.385 | **0.809** | 0.447 |
| SE3 | 0.452 | 0.431 | **0.807** | 0.502 |
| SE4 | 0.407 | 0.364 | **0.781** | 0.435 |
| SE5 | 0.407 | 0.368 | **0.800** | 0.434 |
| TICTI1 | 0.501 | 0.466 | 0.460 | **0.744** |
| TICTI2 | 0.524 | 0.490 | 0.453 | **0.717** |
| TICTI3 | 0.513 | 0.491 | 0.414 | **0.783** |
| TICTI4 | 0.485 | 0.451 | 0.439 | **0.780** |
| TICTI5 | 0.504 | 0.486 | 0.428 | **0.801** |

**Table 8**
Heterotrait-Monotrait Ratio (HTMT) results.

| | AT | DC | SE | TICTI |
|---|---|---|---|---|
| AT | | | | |
| DC | 0.703 | | | |
| SE | 0.605 | 0.568 | | |
| TICTI | 0.768 | 0.739 | 0.679 | |

in the dependent variables that the model predicts, the explanatory power of the model is determined.

#### 4.1.1. Structural model

There are five phases in the structural model evaluation process. The variance inflation factor (VIF) and multicollinearity among all endogenous constructs are first looked at. The t-value and p-value are evaluated in the second phase. Examining the Coefficient of Determination ($R^2$) is the third stage. In the last stage, the effect size ($f^2$) is evaluated, and the model's predictive power ($Q^2$) is evaluated. Reporting the model fit, together with the SRMR and NFI values, is the last step [60].

As expected, there is no problem with multicollinearity; all of the predictors in the model have VIF values less than 5, which qualifies the model for assessment. Inner VIF ratings were utilized by the researchers since all of the elements are reflecting rather than formative. Table 9 displays the inner VIF scores of the predictors in the model. The researchers used a bootstrapping sampling approach using 5000 iterations of a sub-sample to evaluate the assumptions of the structural model. The R square, effect sizes, and Q square are shown in Table 10. When the $R^2$ value for endogenous constructs is 0.25, 0.50, or 0.75, respectively, it is considered weak, moderate, or considerable [60]. Table 8 demonstrates that although the other factors in the model have moderate power, attitudes have low power. Values larger than 0.02, 0.15, and 0.35 are regarded as minor, medium, and high effect sizes ($f^2$), respectively [60]. Table 9 shows that although self-efficacy ($f^2 = 0.398$) has a considerable impact on attitudes, attitudes have a large effect size on digital competence ($f^2 = 0.307$). All three predictors (AT, SE, DC) show a minor impact size when $f^2$ for ICT integration is taken into account.

Using the blindfolding approach, the predictive power of the model was evaluated. Table 10 indicates that the model is predictive because all endogenous constructs had $Q^2$ values larger than zero. To avoid model misspecification, PLS-SEM can use the SRMR as a fit measure. Acceptable SRMR values are those that are less than 0.08 or 0.10. A better match is indicated by values nearer 1 in the NFI range of 0–1 [60]. There is 0.881 NFI. This suggests that the model matches the data rather well, as Table 11 illustrates.

The route analysis is displayed with the assumptions in Table 12 and Fig. 3. The hypotheses between dependent and independent variables are represented by the coefficients' sign, size, and significance. The intensity with which independent factors impact dependent variables is demonstrated by p values, sometimes referred to as coefficient values, in contrast to p values, which indicate the significance of the hypothesis and must be less than.1 [60]. Therefore, all of the hypotheses are accepted at a significance level of.01, and all of the routes are positive, as shown by Table 12 and Fig. 3.

The findings presented above imply that this study's hypotheses are all supported. H1a ($\beta = 0.499$, $p < 00.01$) displays the relationship between attitudes and digital competence, indicating that attitudes unquestionably have a major influence on digital competence when impacting the integration of instructors. Moreover, H2a ($\beta = 0.355$, $p < 00.01$) suggests that attitudes play a major influence in the ICT integration of instructors. Additionally, H3 ($P < 00.01$) shows that attitudes significantly and favorably influence ICTI indirectly through digital competence. Thus, it can be inferred that attitude enhances the digital competence and ICT integration of teachers. H4a ($\beta = 0.534$, $p < 00.01$) and H5a ($\beta = 0.225$, $p < 00.01$), which show how self-efficacy affects attitudes and digital competence under the effect of teacher integration, show how self-efficacy strongly influences attitudes and digital competence. Furthermore, H6a ($\beta = 0.245$, $p < 00.01$), representing the path connecting self-efficacy with ICT integration, suggests that self-efficacy significantly influences teachers' ICT integration. Additionally, H7 ($p < 00.01$) and H8 ($p < 00.01$) predict that self-efficacy influences ICT integration indirectly and significantly through attitudes and digital competency. Thus, a teacher's attitude and aptitude for utilizing technology in the classroom are influenced by their level of self-efficacy. A teacher can successfully use information technology into their lessons if they have a high feeling of self-efficacy. Moreover, H9 ($\beta = 0.220$, $p < 00.01$) shows that digital competence also enhanced the ICT integration of teachers. Fig. 3 shows the suggested model of variables impacting the ICT integration of in-service instructors.

#### 4.1.2. Multi-group analysis

Regarding RQ2, a multi-group analysis was used to examine the remaining hypotheses about the moderating effects of age and gender on the correlations among the four dimensions. Researchers began by conducting variable measurement invariance checks (MICOM). Without MICOM, multi-group analysis cannot be performed [69].

Tables 13 and 14 summarize the findings of the MICOM analysis. Step 1: Normality is automatically established based on the results. Step 2: The permutation p-value is more than 0.05 and the initial correlation is larger than 5 %. Step 3: (a) Since the original difference value is not included in all confidence intervals for the latent variable score means, equal means are not present. (b) Since not all confidence intervals for the latent variable score variances include the initial differences, equal variances are thus absent [70]. These findings allowed us to conduct a multi-group analysis to identify any significant differences based on gender and age.

Table 15 shows that none of the hypotheses could be accepted due to a gender-moderating effect. Gender moderation does not differ between the male and female groups, according to an analysis of the association between these characteristics. Table 16 illustrates this association between attitudes and self-efficacy, the age moderation is greatest in the group of people under 35 years old

**Table 9**
Inner VIF.

| | AT | DC | SE | TICTI |
|---|---|---|---|---|
| AT | | 1.398 | | 1.828 |
| DC | | | | 1.724 |
| SE | 1 | 1.398 | | 1.485 |
| TICTI | | | | |

**Table 10**
R square, effect sizes ($f^2$), and Q square.

| | $R^2$ | $f^2$ | | | | $Q^2$ |
|---|---|---|---|---|---|---|
| | | AT | DC | SE | TICTI | |
| AT | 0.284 | | 0.307 | | 0.154 | 0.201 |
| DC | 0.418 | | | | 0.104 | 0.269 |
| SE | | 0.398 | 0.063 | | 0.091 | |
| TICTI | 0.550 | | | | | 0.318 |

**Table 11**
The model fit parameters.

| | Saturated Model | Estimated Model |
|---|---|---|
| **SRMR** | 0.053 | 0.053 |
| d_ULS | 0.591 | 0.591 |
| d_G | 0.213 | 0.213 |
| Chi-Square | 896.676 | 896.676 |
| **NFI** | 0.881 | 0.881 |

**Table 12**
The results of path analysis and hypothesis.

| Hypo | Paths | Effect type | Beta | T-value | Decision |
|---|---|---|---|---|---|
| H1a | AT - > DC | Direct Effect | 0.499 | 15.942[a] | supported |
| H2a | AT- > TICTI | Direct Effect | 0.355 | 10.501[a] | supported |
| H3 | AT- > DC- > TICTI | Indirect effect | | 7.146[a] | supported |
| H4a | SE - > AT | Direct Effect | 0.534 | 18.053[a] | supported |
| H5a | SE - > DC | Direct Effect | 0.225 | 6.270[a] | supported |
| H6a | SE - > TICTI | Direct Effect | 0.245 | 8.220[a] | supported |
| H7 | SE - > AT- > TICTI | Indirect effect | | 8.474[a] | supported |
| H8 | SE - > DC- > TICTI | Indirect effect | | 4.788[a] | supported |
| H9a | DC - > TICTI | Direct Effect | 0.283 | 8.500[a] | supported |

$p < 0.01$.
$^{**}p < 0.05$.
$^{*}p < 0.10$.

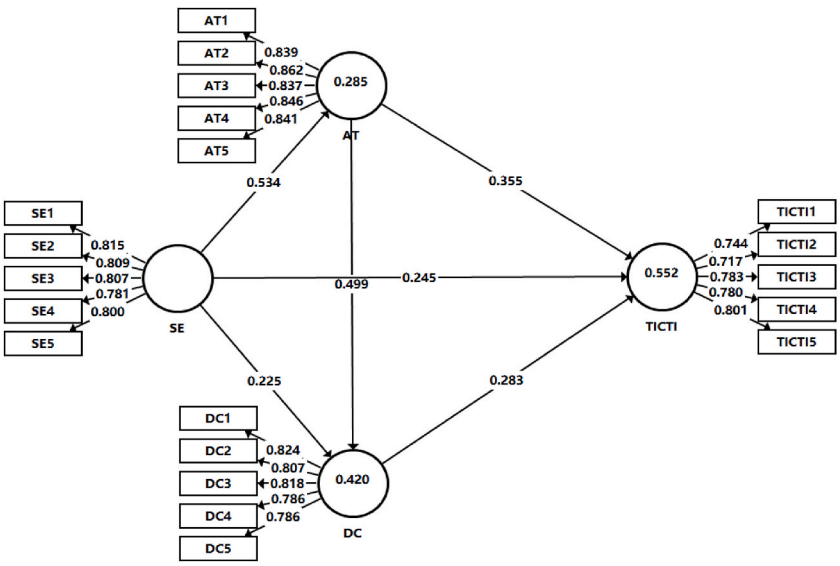



**Fig. 3.** The Model of factors influencing teachers' ICT integration.

**Table 13**
Results of invariance measurement testing using permutation (MICOM) of gender.

| Constructs | Configural Invariance (step 1) | Composition Invariance (Step 2) | | Patrial Measurement Invariance | Equal Mean Assessment (Step 3a) | | Equal Variance Assessment (Step 3b) | | Full Measurement Invariance |
|---|---|---|---|---|---|---|---|---|---|
| | | Original Correlation | 5 % | | Original difference | Confidence Interval | Original difference | Confidence Interval | |
| AT | yes | 1 | 1 | yes | 0.185 | [-0.163; 0.156] | −0.143 | [-0.142; 0.156] | No/No |
| DC | yes | 1 | 0.999 | yes | 0.261 | [-0.170; 0.179] | −0.159 | [-0.158; 0.161] | No/No |
| SE | yes | 0.999 | 0.998 | yes | 0.091 | [-0.174; 0.156] | −0.263 | [-0.154; 0.163] | Yes/No |
| TICTI | yes | 0.999 | 0.998 | yes | 0.05 | [-0.150; 0.166] | −0.135 | [-0.203; 0.235] | Yes/Yes |

**Table 14**
Results of invariance measurement testing using permutation (MICOM) of age.

| Constructs | Configural Invariance (step 1) | Composition Invariance (Step 2) | | Patrial Measurement Invariance | Equal Mean Assessment (Step 3a) | | Equal Variance Assessment (Step 3b) | | Full Measurement Invariance |
|---|---|---|---|---|---|---|---|---|---|
| | | Original Correlation | 5 % | | Original difference | Confidence Interval | Original difference | Confidence Interval | |
| AT | yes | 1 | 1 | yes | −0.154 | [-0.153; 0.158] | −0.001 | [-0.155,0.134] | No/No |
| DC | yes | 1 | 1 | yes | −0.194 | [-0.165; 0.157] | 0.188 | [-0.163,0.141] | No/No |
| SE | yes | 0.999 | 0.999 | yes | −0.171 | [-0.162; 0.148] | 0.389 | [-0.165,0.140] | No/No |
| TICTI | yes | 0.999 | 0.999 | yes | −0.082 | [-0.157; 0.154] | 0.258 | [-0.216,0.198] | Yes/No |

**Table 15**
Multi-group hypothesis testing of gender.

| Hypothesis | Male | | Female | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Path coefficient | CIs (Bias corrected) | Path coefficient | Cis (Bias corrected) | Path coefficient differences | p-value Henseler's MGA | p-value parametric test | supported |
| H1b: AT - > DC | 0.457 | [0.325; 0.561] | 0.513 | [0.441; 0.594] | −0.056 | 0.44 | 0.426 | No |
| H2b: AT- > TICTI | 0.331 | [0.231; 0.451] | 0.365 | [0.281; 0.443] | −0.034 | 0.617 | 0.628 | No |
| H4b: SE - > AT | 0.562 | [0.457; 0.676] | 0.518 | [0.442; 0.588] | 0.044 | 0.518 | 0.513 | No |
| H5b: SE - > DC | 0.255 | [0.121; 0.393] | 0.217 | [0.128; 0.287] | 0.038 | 0.641 | 0.629 | No |
| H6b: SE - > TICTI | 0.260 | [0.145; 0.361] | 0.238 | [0.158; 0.308] | 0.022 | 0.752 | 0.76 | No |
| H9b: DC - > TICTI | 0.289 | [0.186; 0.403] | 0.289 | [0.212; 0.370] | 0.000 | 0.992 | 0.999 | No |

and lowest in the group of people over 36 years old. Age, on the other hand, has no effect on the impact of any other relationships. Accordting to RQ3, Fig. 4 depicts the results of the model's multi-group evaluation.

## 5. Discussion

Contextual variables have been added to the acceptance paradigm, as demonstrated by the incorporation of ICTs in the classroom. This study used PLS-SEM to investigate the factors influencing ICT adoption among educators in a developing country. To determine the variables influencing in-service teachers' use of technology in the classroom, the research integrated the TAM3 and WST models into a single framework. To gain a deeper understanding of teachers' ICT usage, additional characteristics were taken into account, including their attitudes, self-efficacy, and digital competence. The model was found to be sufficient based on the good findings of all validity metrics, including discriminant validity, convergent validity, and Cronbach's alpha. As a result, the variables showed

**Table 16**
Multi-group hypothesis testing of age.

| Hypothesis | ≤35 | | ≥36 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Path coefficient | CIs (Bias corrected) | Path coefficient | CIs (Bias corrected) | Path coefficient differences | p-value Henseler's MGA | p-value parametric test | supported |
| H1c: AT - > DC | 0.558 | [0.424; 0.669] | 0.471 | [0.389; 0.546] | 0.088 | 0.230 | 0.203 | No |
| H2c: AT- > TICTI | 0.408 | [0.262; 0.537] | 0.351 | [0.275; 0.416] | 0.057 | 0.480 | 0.435 | No |
| H4c: SE - > AT | 0.716 | [0.656; 0.770] | 0.405 | [0.313; 0.490] | 0.311 | 0.000[a] | 0.000[a] | Yes |
| H5c: SE - > DC | 0.243 | [0.127; 0.366] | 0.179 | [0.087; 0.263] | 0.065 | 0.398 | 0.397 | No |
| H6c: SE - > TICTI | 0.203 | [0.084; 0.335] | 0.269 | [0.183; 0.328] | −0.067 | 0.374 | 0.324 | No |
| H9c: DC - > TICTI | 0.208 | [0.106; 0.322] | 0.327 | [0.241; 0.403] | −0.118 | 0.105 | 0.900 | No |

$p < 0.01$.
**$p < 0.05$.
*$p < 0.10$.

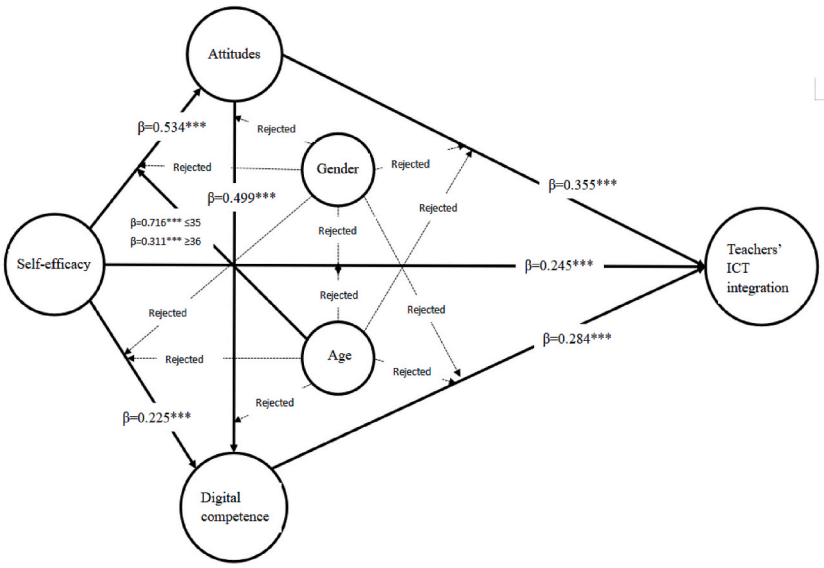



**Fig. 4.** The Final Model of factors influencing teachers' ICT integration.

statistically significant and positive correlations with one another.

Regarding RQ1, this study evaluated the attitudes, self-efficacy, and digital competence of instructors as crucial requirements for improving the effectiveness and productivity of ICT integration. As a result, it's still uncertain if ICT is used to its full potential or not in developing nations. The results of this study show that teachers' attitudes have a considerable beneficial influence on their digital competence and ICT integration, which is consistent with prior studies [29,34,35]. According to the report, educators think that encouraging attitudes encourage pupils to utilize ICT in the classroom, which helps to assist their teaching. Schools in underdeveloped countries should encourage teachers to utilize computers to promote favorable attitudes toward ICT as part of global development [30,31]. Moreover, attitudes have a greater coefficient value than the other two components, indicating a significant influence on ICT integration [49]. The study findings of Clipa et al. (2023) indicate a similar association with the positive correlation ($r = 0.45$, $p < 0.01$) between teachers' views towards technology and their actual usage of it in the classroom [28]. This bolsters the notion that successful technology integration in education requires positive attitudes toward technology.

The study also showed that attitudes, digital competency, and ICT integration were highly impacted by teachers' self-efficacy. These results support the research of Paetsch et al. (2023), who highlighted the significance of self-efficacy in predicting teachers' use of technology. Their research revealed that, with a path coefficient of 0.52 ($p < 0.01$), self-efficacy strongly predicted the adoption of technology [58].This explains why the viewpoints appear difficult or less beneficial to instructors who have poor self-efficacy regarding ICT use. As a result, the results align with other research of a similar nature [17,38], which studies show that better attitudes, digital competency, and ICT integration are displayed by educators who have greater levels of self-efficacy. Furthermore, digital

competence has a favorable impact on teachers' ICT integration. According to earlier studies, educators still need to develop their digital teaching techniques [42,43,47]. The more digitally proficient an educator is, the more adept they are at incorporating technology [17]. To improve teachers' attitudes and self-efficacy in utilizing digital technology, schools and legislators must continue to create fair rules that motivate educators to improve their digital abilities and actively engage in digital technology training. To use ICT in the classroom and improve the caliber of their education, educators must also concentrate on honing their digital abilities [56].

Subsequently, in relation to RQ2, this research model helps test the differences between gender and age factors influencing teachers' ICT integration. Consistent with previous research [6,54], the findings showed that there was no discernible gender difference in the correlations between the variables. China has a long history of promoting gender equality, which has led to a small gender gap in education and no appreciable differences in these areas between men and women [32]. Initially, the utilization of ICT in education relies chiefly on the proficiency of teachers in operating the technology and employing it for teaching, rather than being contingent upon their gender. The adaptability in utilizing technology within classroom instruction is primarily determined by an individual's skill set and training, rather than their gender identity [6]. Additionally, the advancement and widespread adoption of ICT has afforded educators the chance to partake in training and gain relevant knowledge, irrespective of their gender. All genders may typically access a wide range of digital tools and teacher education programs, giving educators the chance to incorporate technology into their pedagogical approaches [41]. Furthermore, the gender of teachers does not have a direct correlation with their pedagogical philosophy or professional growth. ICT integration in education is more directly correlated with curriculum design, student needs, and pedagogical goals of teachers—factors that are not contingent on the gender of the instructor [40]. Hence, the gender of a teacher does not serve as the pivotal determinant in the application of ICT in education. Rather, the essential factors include the technical proficiency of the teacher, their instructional strategies, their openness to technology, and their willingness to implement it. Gender should not serve as the primary criterion for evaluating the capabilities and potential of teachers in utilizing ICT for teaching purposes.

The findings also showed that most correlations between variables do not significantly change based on the age of the variables. However, teachers aged $\leq$35 have significantly stronger age moderation between self-efficacy and attitudes than teachers aged $\geq$36. Younger educators are prone to embracing fresh technologies and incorporating them into their teaching practices. Their increased exposure to a variety of digital tools during their upbringing has fostered a greater familiarity and comfort with technology and digital surroundings [35]. Furthermore, these younger teachers might have undergone more extensive training in digital education or encountered more instances of technology implementation within educational curricula, thus instilling in them a heightened sense of assurance and proficiency in employing technology [17,40]. Ultimately, the younger demographic tends to display a more proactive approach towards exploring and adjusting to novel concepts, displaying a greater readiness to experiment and acquire new technological skills, thereby displaying more enthusiasm towards digital teaching practices [40]. The absence of a direct correlation between age and digital proficiency can be attributed to the fact that, while age might influence how open and receptive an individual is to technology, digital skills are primarily contingent on an individual's inclination to learn, technical training, and ongoing education. Age, in itself, does not serve as a definitive factor in determining a person's digital skills; instead, it is an individual's mindset and the opportunities they have to acquire and adapt to new technologies that play a more pivotal role [15]. Therefore, teachers of all ages can be seen as the driving force behind digital education. Enhancing training for both younger and older teachers is crucial when it comes to digital technology abilities.

Regarding RQ3, based on the findings from the first two research questions, a comprehensive model is proposed to enhance ICT integration among teachers. Important elements covered by this approach are teachers' attitudes toward technology, their level of self-efficacy, their level of digital competency, and the particular difficulties they face. Key components include tailored professional development programs, ongoing support and mentorship, enhanced access to technology, and resource allocation. It also focuses on attitudinal and motivational support, collaborative networks, and partnerships with ICT experts. Additionally, the model emphasizes policy and administrative support, developing supportive policies, and encouraging administrative leadership. The implementation of this model should be phased, with pilot programs and robust feedback mechanisms to allow for iterative improvements. The suggested strategy seeks to increase ICT adoption in educational settings, raising the standard of instruction and better preparing students for the digital era by addressing professional development, infrastructure, attitudinal support, collaboration, and policy.

## 6. Conclusion

This research provides educators with a fresh resource for enhancing their pedagogical practices by highlighting the factors involved in ICT integration. The results indicate that teachers' attitudes, self-efficacy, and digital competence can all affect their ICT integration, which means that the management of educational institutions should recognize the relevance of teachers' roles in this process. The results, therefore, suggest that to successfully integrate ICT into the classroom, support, and resources should be made available to the teachers.

There are many restrictions on this study. First off, the results cannot be applied universally because the data were gathered in China's Henan Province. It is advised that future research collect information from educators abroad. Furthermore, the results might not apply to other courses because this study only included teachers of a single language subject. Subsequent studies must to think about involving educators with diverse topic backgrounds. The sample size represents the third constraint. Despite the fact that the sample included a heterogeneous mix of educators from different kinds of schools, there might not have been enough participants overall to apply the results to all Chinese educators. A bigger sample size would be advantageous for future studies in order to improve the results' generalizability.

The study's conclusions have significant real-world ramifications for Chinese educational policy and practice. Firstly, educational policymakers should develop and implement comprehensive professional development programs aimed at improving teachers'

attitudes towards technology, self-efficacy, and digital competence. Schools should integrate ICT skills into the curriculum for both teachers and students to ensure effective digital tool usage. Additionally, investing in supportive technological infrastructure, such as reliable internet and modern devices, is crucial. Developing collaborative platforms for teachers to share best practices can further support ICTintegration. Larger and more varied sample sizes, longitudinal studies to monitor changes over time, and qualitative techniques to identify contextual elements should all be a part of future study. Deeper insights may be obtained by examining the effects of particular ICT tools on teaching and learning and evaluating the efficacy of educational policies. This study directs stakeholders toward better educational practices and results by highlighting the critical roles that attitudes, self-efficacy, and digital competence play in ICT integration in China.

## Institutional review board statement

Approval was obtained from the Committee of Ethics and Deontology of Research at the University and the number is UM. TNC2/UMREC_2298.

## Institutional review board statement

This study was reviewed and approved by the Universiti Malaya Research Ethics Committee with the approval number: UM. TNC2/UMREC_2298, dated January 2023.

## Informed consent statement

All participants provided written informed consent to participate in the study and for their data to be published.

## Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## CRediT authorship contribution statement

**Ran Peng:** Writing – original draft. **Rafiza Abdul Razak:** Writing – original draft. **Siti Hajar Halili:** Writing – review & editing.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e34234.

## References

[1] S. Luo, D. Zou, A systematic review of research on technological, pedagogical, and content knowledge (TPACK) for online teaching in the humanities, J. Res. Technol. Educ. (2022) 1–15.
[2] I.M. Sutama, et al., ICT utilization in Indonesian language learning at the junior high school level in Buleleng Regency, Bali, Indonesia, International Journal of Information and Education Technology 12 (9) (2022) 947–955.
[3] R.J. Fakhlina, L. Lolytasari, L. Rahmi, A systematic literature review of knowledge sharing based on ICT during COVID-19 ERA, in: 2022 10th International Conference on Cyber and IT Service Management (CITSM), IEEE, 2022.
[4] S.M. Tsegay, et al., Online teaching during COVID-19 pandemic: teachers' experiences from a Chinese university, Sustainability 14 (1) (2022) 568.
[5] X. Li, P.A. Shaikh, S. Ullah, Exploring the potential role of higher education and ICT in China on green growth, Environ. Sci. Pollut. Control Ser. 29 (43) (2022) 64560–64567.
[6] M.O. Ogalo, C. Omulando, P. Barasa, Assessment of Teachers' Technological and Pedagogical Knowledge of Integrating ICT in Teaching English in Secondary Schools in Nairobi County, Kenya, 2022.
[7] T. Dolighan, M. Owen, Teacher efficacy for online teaching during the COVID-19 pandemic, Brock Education Journal 30 (1) (2021) 95, 95.
[8] D. Lu, Y.-N. Xie, Critical thinking cultivation in TESOL with ICT tools: a systematic review, Comput. Assist. Lang. Learn. 37 (1–2) (2024) 222–242.
[9] Q. Wang, G. Zhao, ICT self-efficacy mediates most effects of university ICT support on preservice teachers' TPACK: evidence from three normal universities in China, Br. J. Educ. Technol. 52 (6) (2021) 2319–2339.
[10] V. Kumar, et al., Adoption of ICTs as an emergent business strategy during and following COVID-19 crisis: evidence from Indian MSMEs, Benchmark Int. J. 30 (6) (2023) 1850–1883.
[11] L. Zhou, et al., 'School's out, but class' on', the largest online education in the world today: taking China's practical exploration during the COVID-19 epidemic prevention and control as an example, Best evid chin edu 4 (2) (2020) 501–519.
[12] M. Ma, et al., Factors affecting EFL teachers' affordance transfer of ICT resources in China, Interact. Learn. Environ. 30 (6) (2022) 1044–1059.

[13] X. Lai, et al., Classes of problematic smartphone use and information and communication technology (ICT) self-efficacy, J. Appl. Dev. Psychol. 83 (2022) 101481.
[14] C.H. Liao, et al., Exploring the relationship between computational thinking and learning satisfaction for non-STEM college students, International Journal of Educational Technology in Higher Education 19 (1) (2022) 43.
[15] B.A. Lukas, M.M. Yunus, ESL teachers' challenges in implementing E-learning during COVID-19, International Journal of Learning, Teaching and Educational Research 20 (2) (2021) 330–348.
[16] R.V. Staddon, Bringing technology to the mature classroom: age differences in use and attitudes, International Journal of Educational Technology in Higher Education 17 (1) (2020) 11.
[17] J. Šabić, B. Baranović, S. Rogošić, Teachers' self-efficacy for using information and communication technology: the interaction effect of gender and age, Inf. Educ. 21 (2) (2022) 353–373.
[18] V. Venkatesh, H. Bala, Technology acceptance model 3 and a research agenda on interventions, Decis. Sci. J. 39 (2) (2008) 273–315.
[19] P.C. Lai, The literature review of technology adoption models and theories for the novelty technology, JISTEM-Journal of Information Systems and Technology Management 14 (2017) 21–38.
[20] D.A. Jeffrey, Testing the technology acceptance model 3 (tam 3) with the inclusion of change fatigue and overload, in: The Context of Faculty from Seventh-Day Adventist Universities: A Revised Model, Andrews University, 2016.
[21] S. Duan, M. Exter, T. Newby, Effect of best possible self writing activities on preservice teachers' attitudes towards technology integration, TechTrends 66 (4) (2022) 654–665.
[22] R. Christensen, G. Knezek, Self-report measures and findings for information technology attitudes and competencies, International handbook of information technology in primary and secondary education, (2008) 349–365.
[23] M. Multazam, Z. Syahrıal, R. Rusmono, Development of learning models in web programming courses with computer-based learning tutorials, Turk. Online J. Dist. Educ. 24 (2) (2023) 232–244.
[24] G.M. Smith, et al., The Western stemmed tradition: problems and prospects in Paleoindian archaeology in the Intermountain West, PaleoAmerica 6 (1) (2020) 23–42.
[25] L. Lin-Schilstra, et al., Consumers' view on pork: consumption motives and production preferences in ten European Union and four non-European Union countries, Meat Sci. 187 (2022) 108736.
[26] P. Marchlik, K. Wichrowska, E. Zubala, The use of ICT by ESL teachers working with young learners during the early COVID-19 pandemic in Poland, Educ. Inf. Technol. 26 (6) (2021) 7107–7131.
[27] A. Haleem, et al., Understanding the role of digital technologies in education: a review, Sustainable Operations and Computers 3 (2022) 275–285.
[28] O. Clipa, C.-S. Delibas, L. Mâță, Teachers' self-efficacy and attitudes towards the use of information technology in classrooms, Educ. Sci. 13 (10) (2023) 1001.
[29] A.A. Cattaneo, C. Antonietti, M. Rauseo, How digitalised are vocational teachers? Assessing digital competence in vocational education and looking at its underlying factors, Comput. Educ. 176 (2022) 104358.
[30] M. Núñez-Canal, M.d.l.M. de Obesso, C.A. Pérez-Rivero, New challenges in higher education: a study of the digital competence of educators in Covid times, Technol. Forecast. Soc. Change 174 (2022) 121270.
[31] J.B. Torrato, M.S. Prudente, S.E. Aguja, Technology integration, proficiency and attitude: perspectives from grade school teachers, in: Proceedings of the 2020 11th International Conference on E-Education, E-Business, E-Management, and E-Learning, 2020.
[32] Y. Zhao, A.M.P. Llorente, M.C.S. Gómez, Digital competence in higher education research: a systematic literature review, Comput. Educ. 168 (2021) 104212.
[33] Ö.F. Ursavaş, Y. Yalçın, E. Bakır, The effect of subjective norms on preservice and in-service teachers' behavioural intentions to use technology: a multigroup multimodel study, Br. J. Educ. Technol. 50 (5) (2019) 2501–2519.
[34] N. Pongsakdi, A. Kortelainen, M. Veermans, The impact of digital pedagogy training on in-service teachers' attitudes towards digital technologies, Educ. Inf. Technol. 26 (5) (2021) 5041–5054.
[35] T.N. Bariu, X. Chun, Influence of teachers attitude on ict implementation in kenyan universities, Cogent Education 9 (1) (2022) 2107294.
[36] J. Paetsch, B. Heppt, J. Meyer, Pre-service teachers' beliefs about linguistic and cultural diversity in schools: the role of opportunities to learn during university teacher training, in: Frontiers in Education, Frontiers Media, 2023.
[37] A. Yada, et al., Meta-analysis of the relationship between teachers' self-efficacy and attitudes toward inclusive education, Teach. Teach. Educ. 109 (2022) 103521.
[38] B.R. Zubković, R. Pahljina-Reinić, S. Kolić-Vehovec, Predictors of ICT use in teaching in different educational domains, Humanities Today: Proceedings 1 (1) (2022) 75–91.
[39] M. Mehrvarz, et al., The mediating role of digital informal learning in the relationship between students' digital competence and their academic performance, Comput. Educ. 167 (2021) 104184.
[40] N. Şen, H. Yildiz Durak, Examining the relationships between English teachers' lifelong learning tendencies with professional competencies and technology integrating self-efficacy, Educ. Inf. Technol. 27 (5) (2022) 5953–5988.
[41] S. Baroudi, N. Shaya, Exploring predictors of teachers' self-efficacy for online teaching in the Arab world amid COVID-19, Educ. Inf. Technol. 27 (6) (2022) 8093–8110.
[42] M. Pozas, V. Letzel, C. Schneider, 'Homeschooling in times of corona': exploring Mexican and German primary school students' and parents' chances and challenges during homeschooling, Eur. J. Spec. Needs Educ. 36 (1) (2021) 35–50.
[43] J. Tondeur, et al., A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: mind the gap, Australas. J. Educ. Technol. 33 (3) (2017).
[44] L. Tang, J. Gu, J. Xu, Constructing a digital competence evaluation framework for in-service teachers' online teaching, Sustainability 14 (9) (2022) 5268.
[45] F. Megawati, et al., How confident are EFL prospective teachers toward technology, Lensa: Kajian Kebahasaan, Kesusastraan, dan Budaya 10 (2) (2020) 137–151.
[46] M. Lucas, et al., The relation between in-service teachers' digital competence and personal and contextual factors: what matters most? Comput. Educ. 160 (2021) 104052.
[47] Z. Liu, et al., Effects of computer-based mind mapping on students' reflection, cognitive presence, and learning outcomes in an online course, Dist. Educ. 44 (3) (2023) 544–562.
[48] S. Liu, et al., Computer-supported collaborative concept mapping: the impact of students' perceptions of collaboration on their knowledge understanding and behavioral patterns, Interact. Learn. Environ. 31 (6) (2023) 3340–3359.
[49] M. Estaji, K. Zhaleh, The enactment of classroom justice through explicit instruction: deciphering the changes in English as a foreign language teachers' perceptions and practices, Front. Psychol. 13 (2022) 821763.
[50] M. Mahdum, H. Hadriana, M. Safriyanti, Exploring teacher perceptions and motivations to ict use in learning activities in Indonesia, J. Inf. Technol. Educ. 18 (2019).
[51] K. Makhlouf, Z. Bensafi, An exploration of factors influencing teachers' attitudes toward the use of Information and Communication Technology (ICT) in classroom practice A Case study of secondary school EFL teachers in the Western District of Chlef, Algeria, Adv. Lang. Lit. Stud. 12 (2) (2021) 37–49.
[52] A. Semerci, M.K. Aydin, Examining high school teachers' attitudes towards ICT use in education, Int. J. Prog. Educ. 14 (2) (2018) 93–105.
[53] R. Kalra, Experienced and novice teachers' awareness and attitudes towards ICT in language classroom: a study conducted in a Thai context, Arab World English Journal (AWEJ) Special Issue on CALL (4) (2018).
[54] O.I. Ikwuka, et al., Teachers' attitude towards the use of ICT for quality instructional delivery in Onitsha North secondary schools, Anambra State, Nigeria, Int. J. Acad. Res. Prog. Educ. Dev. 9 (3) (2020) 1–11.
[55] A. Perienen, A. Al Sultan, Teaching attitude, is A psychological tendency of teachers towards students, teaching process and relative teaching, Eurasia J. Math. Sci. Technol. Educ. 16 (6) (2020) em1845.

[56] C. Blundell, K.-T. Lee, S. Nykvist, Moving beyond enhancing pedagogies with digital technologies: frames of reference, habits of mind and transformative learning, J. Res. Technol. Educ. 52 (2) (2020) 178–196.
[57] Y. Yondler, I. Blau, What is the degree of teacher centrality in optimal teaching of digital literacy in a technology-enhanced environment? Typology of teacher prototypes, J. Res. Technol. Educ. 55 (2) (2023) 230–251.
[58] M. Pedaste, K. Kallas, A. Baucal, Digital competence test for learning in schools: development of items and scales, Comput. Educ. 203 (2023) 104830.
[59] M. Estaji, K. Zhaleh, IRANIAN efl TEACHERS'EXPECTATIONS and perceptions about teacher classroom justice training, TEFLIN Journal 33 (2) (2022) 272–291.
[60] J.F. Hair, et al., When to use and how to report the results of PLS-SEM, Eur. Bus. Rev. 31 (1) (2019) 2–24.
[61] H. Qingle, An analysis of ways to revitalize rural family education—taking henan as an example, Transactions on Comparative Education 6 (2) (2024) 29–35.
[62] M.T. Borsi, O.M.V. Mendoza, F. Comim, Measuring the provincial supply of higher education institutions in China, China Econ. Rev. 71 (2022) 101724.
[63] K. Leighton, et al., Using social media and snowball sampling as an alternative recruitment strategy for research, Clinical simulation in nursing 55 (2021) 37–42.
[64] J.P. Hernández-Ramos, et al., Teachers' attitude regarding the use of ICT. A factor reliability and validity study, Comput. Hum. Behav. 31 (2014) 509–516.
[65] K. Banoglu, R. Vanderlinde, R. Yildiz, Professional self-efficacy scale for information and computer technology teachers: validity and reliability study, Anthropol. 20 (1–2) (2015) 22–32.
[66] S. Ghavifekr, W.A.W. Rosdy, Teaching and learning with technology: effectiveness of ICT integration in schools, International journal of research in education and science 1 (2) (2015) 175–191.
[67] A. Gutiérrez-Martín, R. Pinedo-González, C. Gil-Puente, ICT and Media competencies of teachers. Convergence towards an integrated MIL-ICT model, Comunicar 30 (70) (2022) 21–33.
[68] T.A. Kyriazos, Applied psychometrics: sample size and sample power considerations in factor analysis (EFA, CFA) and SEM in general, Psychology 9 (8) (2018) 2207.
[69] J. Henseler, C.M. Ringle, M. Sarstedt, Testing measurement invariance of composites using partial least squares, Int. Market. Rev. 33 (3) (2016) 405–431.
[70] L. Matthews, Applying multigroup analysis in PLS-SEM: a step-by-step process, Partial least squares path modeling: Basic concepts, methodological issues and applications (2017) 219–243.