Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-023-01871-z OPEN

# Investigating the factors affecting ICT integration of in-service teachers in Henan Province, China: structural equation modeling

Ran Peng[1], Rafiza Abdul Razak[1]✉ & Siti Hajar Halili[1]

The integration of Information and Communication Technology (ICT) can significantly improve teaching and learning outcomes, but various factors determine the degree to which ICT is integrated into educational practices. This study used quantitative methodology to examine four key factors that impact in-service teachers' ICT integration and how they interact with each other. Data was collected through snowball sampling from 685 in-service teachers in Henan Province, China. Using partial least squares structural equation modeling (PLS-SEM), the study analyzed four factors from the Technology Acceptance Model 3 (TAM 3) and the Will-Skill-Tool model (WST model): attitudes (AT), self-efficacy (SE), digital competence (DC), and digital tools utilization (DTU). The findings revealed that all four elements exerted a noteworthy influence on the integration of ICT by in-service instructors. Meanwhile, attitudes, digital competence, and digital tools utilization have a mediating effect in this research. Additionally, the study examined how gender, age, and teaching experience influence these factors and ICT integration. The findings revealed that females exhibit higher levels of positive attitudes and digital competence than males, while teachers aged 31–35 years have stronger digital abilities, digital tool use, and ICT integration compared to younger or older teachers. Furthermore, teachers with less than three years of teaching experience exhibit significantly stronger attitudes, self-efficacy, digital competence, and ICT integration than those with more than ten years of experience. The implication of the study provides valuable insights for designing effective ICT-based instruction and developing teacher education and educational technology programs aimed at promoting ICT integration in the classroom.

[1] Department of Curriculum & Instructional Technology, Faculty of Education, University Malaya, Kuala Lumpur, Malaysia. ✉email: rafiza@um.edu.my

## Introduction

The adoption of information and communications technology (ICT) in the education sector has sparked concerns. It is deemed necessary to utilize ICT in education to transform the outdated educational system (LeTendre, 2022). Despite instructors' proficiency and comfort with ICT, their active utilization of it remains limited and supplementary (Pham and Sampson, 2022). Scholars have shown considerable interest in studying the impact of ICT on educational systems, especially in developing nations such as China (Li et al., 2022; Pokhrel and Chhetri, 2021; Tsegay et al., 2022). Some researchers have investigated specific obstacles that impede teachers from implementing ICT in the classroom, while others have employed technology-adoption models to address potential reasons behind teachers' hesitance to incorporate ICT in their teaching practices (Dolighan and Owen, 2021; Ogalo et al., 2022). Recognizing the belief that enhancing ICT in schools will have extensive pedagogical and educational benefits for educators and students alike, efforts have been made to upgrade the necessary technological infrastructure and ICT-based tools for instruction and learning (Wang and Zhao, 2022). Nonetheless, there exists a risk of disillusionment with the promised advantages of integrating ICT in the classroom (Kumar et al., 2022). Consequently, it is crucial to ascertain why and under what circumstances ICT integration proves to be an effective instructional tool.

When implemented appropriately in educational settings, the integration of ICT can serve as a valuable tool to support and enhance the learning process. The active involvement of teachers is fundamental to ensure the effective integration of ICT in the classroom (Seufert et al., 2021). The use of ICT by teachers plays a significant role in students' learning outcomes, as it not only enhances their motivation but also enables them to utilize ICT more proficiently (Aidoo et al., 2022). Scholars have thus conducted investigations to identify the factors that either facilitate or hinder teachers' incorporation of ICT into their teaching practices. Several factors associated with ICT use have been recognized, encompassing attitudes, self-efficacy, prior experience with ICT, and competencies in ICT (Busse et al., 2022). Despite considerable efforts to support teachers in integrating ICT into their classroom practices by identifying these facilitating and inhibiting factors, the existing literature indicates that teachers seldom utilize ICT (Cabero-Almenara et al., 2021).

The implementation of information technology in education is fraught with numerous challenges. Many teachers simply transfer their classroom teaching materials to online courses without considering personalized guidance, student engagement, and ultimately fail to achieve effective teaching outcomes. These concerns revolve around finding ways to enhance the synergy between technology and education, including facilitating independent student learning, improving teacher training, and successfully integrating online teaching models (Zhou et al., 2020). Despite the adoption of certain policies, only a limited number of teachers in China, with varying levels of professional experience, have received sufficient training on effectively incorporating technology in their classrooms. Insufficient utilization of technology by teachers can impede students' development and hinder their progress (Ma et al., 2019).

Existing research on perceived barriers to the integration of technology in teaching has shown limited emphasis on the underlying influencing factors (Lai et al., 2022; Liao et al., 2022). Moreover, there is a dearth of studies that specifically investigate the utilization of ICT-based education by instructors (Lukas and Yunus, 2021). Additionally, the majority of previous research has predominantly relied on a singular model of technology acceptability, with only a few studies successfully integrating both models (Lu and Xie, 2022). Consequently, there is a pressing need to acquire a deeper comprehension of the factors that influence teachers' adoption of ICT. This understanding is essential for enhancing their capabilities and fostering effective teacher-student interaction with technology.

The primary objective of this study is to investigate two research questions. (1) What are the associations among attitudes, self-efficacy, digital competence, digital tools utilization, and ICT integration among in-service teachers? (2) What association exists between the demographic characteristics of in-service teachers, such as age, gender, and teaching experience, and their impact on ICT integration?

## Literature review

**Theoretical framework**. The underlying theoretical foundations are derived from the Technology Acceptance Model 3 (TAM 3) and the Will-Skill-Tool model (WST model) in this investigation. TAM 3 is a theoretical framework that delves into the factors and processes related to the acceptance and practical utilization of new technology among individuals from diverse backgrounds (Venkatesh and Bala, 2008). On the other hand, the WST model encompasses three essential components—will, skill, and tool—that are indispensable for the successful integration of digital technology into classroom practices (Christensen and Knezek, 2008). Both TAM 3 and the WST model explore the factors influencing the actual usage of technology in real-world settings, although they adopt distinct approaches. While TAM 3 focuses on the cognitive aspects associated with the widespread adoption of new technologies, the WST model concentrates on more intricate elements that impact the integration of ICT.

The process of adoption presents formidable challenges, necessitating substantial exertion in the examination and evaluation of its impact on educators. Consequently, it is imperative to employ these theories as a conceptual framework to foster a comprehensive and comprehensive comprehension of ICT integration among teachers. This can be accomplished by monitoring pertinent characteristics, including attitudes, self-efficacy, digital competence, and digital tools utilization, in conjunction with the TAM3 model and the WST model. The subsequent phase involves academic inquiry into how these characteristics exert influence on the adoption of ICT among instructors currently in service.

**Attitudes**. Numerous research studies have presented evidence of a favorable influence of attitudes on the integration of ICT, emphasizing the significance of teachers maintaining a positive stance when utilizing ICT efficiently and creatively (Bariu & Chun, 2022; Ursavaş et al., 2019; Verma et al., 2018). Multiple investigations have explored the associations between teachers' attitudes, their digital competency, and their digital tools utilization (Al-dheleai et al., 2019; Pozas and Letzel, 2021; Štemberger and Konrad, 2021). Findings have revealed that teachers' perspectives exert a substantial impact on their level of digital competence and the extent to which they utilize digital resources. Notably, instructors possessing ICT skills demonstrated enthusiasm for integrating ICT into their teaching practices. Moreover, teachers' attitudes regarding the adoption of digital technology in education emerged as a pivotal predictor of their proficiency level.

Teachers' viewpoints concerning the integration of ICT into their instructional practices are shaped by various factors, encompassing but not limited to age, gender, and teaching experience. Mannila et al. (2018) postulated a connection between a teacher's age group and their attitude toward ICT integration in the classroom, a trend observed across both male and female

educators. Furthermore, Kalra (2018) discovered that novice teachers displayed a more optimistic perspective on the utilization of ICT in teaching when compared to their more seasoned counterparts. However, several studies have found no discernible disparity in the use of ICT or attitudes among instructors based on gender, age, or experience level (Semerci and Aydin, 2018; Ikwuka et al., 2020).

Consequently, it is discernible that teachers' attitudes wield a substantial influence on their digital proficiency, enabling them to adeptly employ digital tools and incorporate ICT. Moreover, the variables of gender, age, and teaching experience within the educator cohort possess the potential to exert discernible effects on the various facets associated with ICT integration.

**Self-efficacy**. The preceding studies presented in this discourse provide substantiation for the positive association between teachers' self-efficacy and their attitudes toward ICT integration (Yada et al., 2022). However, it is worth noting that certain studies have also established the absence of a relationship between teachers' self-efficacy and their attitudes (Arhin et al., 2022; Coban and Atasoy, 2019). Data gleaned from multiple studies imply that teachers' self-efficacy plays a role in shaping their digital competence when it comes to ICT integration (Hatlevik and Hatlevik, 2018; Peciuliauskiene et al., 2022). Nevertheless, it should be acknowledged that Backfisch et al. (2021) discovered that digital competence does not exert an influence on self-efficacy. Limited research attention has been dedicated to examining the nexus between self-efficacy and digital tools utilization during ICT integration. Alhassan (2017) affirmed the significant impact of teachers' self-efficacy on digital tools utilization.

Furthermore, some studies have suggested that there is no discernible disparity concerning the influence of age, gender, teaching experience, and self-efficacy on ICT integration (Baroudi and Shaya, 2022; Dolighan and Owen, 2021). Nevertheless, it is important to highlight that specific researchers have confirmed divergent results (Şen and Yildiz, 2022; Šabić et al., 2021).

**Digital competence**. There is emerging evidence suggesting a significant association between digital competence and the integration of ICT. It is suggested that educators require further development of their digital teaching skills (Dwiono et al., 2018; Fominykh et al., 2021; Méndez et al., 2022). Additionally, several studies have corroborated the impact of self-efficacy and attitudes on digital competence. Teachers who perceive themselves as lacking self-efficacy or holding unfavorable attitudes often demonstrate reduced self-confidence, subsequently affecting their digital competence and their ability to provide optimal learning opportunities for their students (Mannila et al., 2018; Ogodo et al., 2021).

Limited research has been conducted on the correlation between digital competence and gender and age. Lucas et al. (2021) discovered that females exhibit lower levels of digital competence compared to males, while younger teachers demonstrate higher competence in utilizing digital technologies than their older counterparts. Conversely, Zhou et al. (2021) argued that gender and age have a minimal impact on digital competence.

**Digital tools utilization**. ICT devices encompass a range of technological tools including computers, laptops, printers, scanners, software programs, data projectors, and interactive teaching devices (Nuhu and Onojah, 2021). These tools form a repertoire of modern technologies that enhance the efficient transmission of information, transforming people's information retrieval capabilities and shaping their interpersonal engagements (Lavrenova et al., 2020).

Numerous research investigations have provided empirical evidence supporting the direct influence of digital tools on the integration of ICT among teachers (Al-Maroof and Salloum, 2020; Antonietti et al., 2022; Fearnley and Amora, 2020). The incorporation of ICT has become an essential prerequisite for the advancement of educational initiatives and policies. By equipping teachers with comprehensive training, ICT resources enable them to refine their digital competencies and enhance the teaching-learning process through dynamic and innovative approaches (Amhag et al., 2019). Consequently, the utilization of ICT tools enhances the effectiveness of teaching and learning endeavors. Moreover, the exploration of how a teacher's age, gender, or teaching experience influences their digital tools utilization remains a relatively understudied area. To summarize, Fig. 1 illustrates the conceptual framework underpinning this study.

## Methodology

**Research design**. In this research, a statistical technique called partial least squares structural equation modeling (PLS-SEM) is utilized to establish a framework that combines the third version of TAM3 and the WST model. The aim is to forecast and clarify the various elements that impact the integration of ICT among teachers currently employed in the education sector. The proposed framework investigates the correlation between ICT integration and four key variables under examination: attitudes (AT), self-efficacy (SE), digital competence (DC), and digital tools utilization (DTU).

**Sampling and data collection**. For this research, a group of teachers in Henan Province, China, was selected as the sample, as the study focused on examining the integration of ICT among educators in developing countries. Henan Province, being a resource-rich Chinese province with a significant teacher population, was deemed representative of typical developing nations. The sampling technique employed was snowball sampling, a probability-based approach. The researchers contacted 20 in-service teachers from various public schools in Henan Province, who were then responsible for collecting data from a minimum of 40 other in-service instructors. The survey was conducted over four weeks, starting from December 2022, and concluding in January 2023. An online platform was utilized to distribute 800 questionnaires, resulting in the collection of 720 valid responses. This sample size was considered sufficient to represent the overall population, ensuring the study's reliability (Hair et al., 2019). Participants who voluntarily provided informed consent also shared demographic details, such as gender, age, and teaching experience. Strict measures were taken to uphold the confidentiality of the information provided, adhering to ethical standards set by the study.

The sample encompasses all the valid submissions received through the online platform. After eliminating outliers and missing data, the dataset was narrowed down to 685 usable responses. In terms of gender distribution, males accounted for 30.7% of the participants, while females constituted 69.3%. The majority of instructors were below the age of 45, with only 14.2% being older. Among the participants, 62.5% had less than three years of teaching experience, whereas a mere 2% had accumulated over 30 years of expertise (refer to Table 1).

**Research instrument**. To collect the necessary data, a questionnaire was employed to predict the factors that influence the integration of ICT among in-service teachers. The questionnaire consisted of multiple components, namely attitudes (AT), self-efficacy (SE),

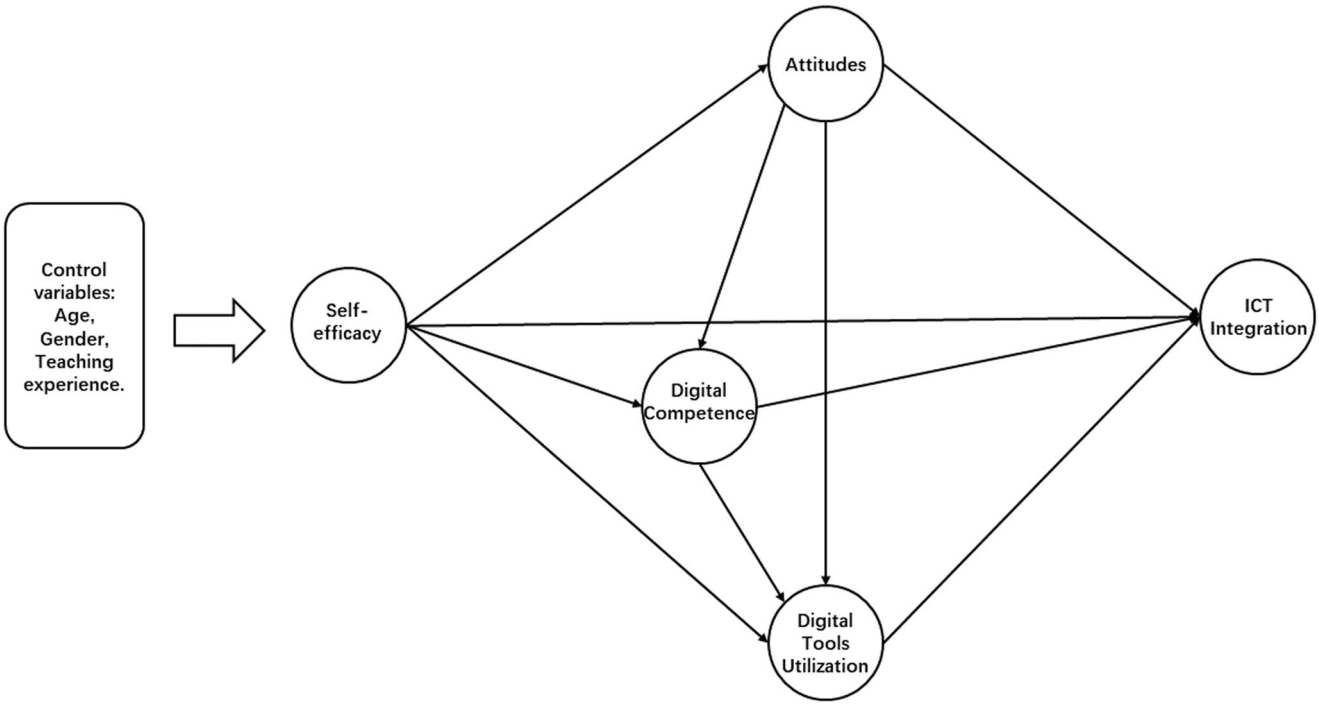


**Fig. 1 The conceptual framework of the research.** The impact of attitude, self-efficacy, digital competence, and digital tools utilization on ICT integration and the relationship among the four independent variables.

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

| Variables | Number | Percent (%) |
|---|---|---|
| **Gender** | | |
| Male | 210 | 30.7 |
| Female | 475 | 69.3 |
| **Age** | | |
| 1. 20–30 | 200 | 29.2 |
| 2. 31–35 | 231 | 33.7 |
| 3. 36–45 | 157 | 22.9 |
| 4. 46–55 | 65 | 9.5 |
| 5. >55 | 32 | 4.7 |
| **Teaching experience** | | |
| 1. <3 years | 428 | 62.5 |
| 2. 4–10 years | 170 | 24.8 |
| 3. 11–20 years | 57 | 8.3 |
| 4. 21–30 years | 16 | 2.3 |
| 5. >30 years | 14 | 2 |

digital competence (DC), digital tools utilization (DTU), and ICT integration (ICTI), all of which were integral to the proposed model. A 5-point Likert scale was utilized to gauge the responses, ranging from "strongly disagree" to "strongly agree," allowing for effective factor measurement. The questionnaire items were adapted and modified from previous studies, ensuring their relevance and appropriateness. Furthermore, all constructs within the questionnaire demonstrated a commendable level of reliability, as evidenced by the satisfactory Cronbach's alpha value of 0.95 (refer to Table 2 for further details).

## Results

In this study, a resampling technique involving 5000 subsamples is utilized in conjunction with the smart PLS 3.3.3 algorithm. PLS-SEM proves to be a suitable alternative to covariance-based structural equation modeling when there is limited prior knowledge about the relationships within the structural model or the measurement of its components. The primary aim of employing the PLS method is to predict indicators by expanding the sets of components. If the objective is to forecast essential target constructs or identify key constructs, PLS-SEM should be the preferred choice. Additionally, PLS-SEM is the optimal approach for research endeavors characterized by exploration or an extension of an existing structural theory (Hair et al., 2019).

**Measurement model**. When assessing a measurement model, the key criteria to consider are reliability and validity. Table 3 presents the results of the reliability test, which was conducted to assess the consistency of the items within the constructs. To examine the convergent validity and discriminant validity of the construct, the validity test was carried out, and the findings are displayed in Tables 4 and 5. Table 3 provides Cronbach's alpha value for each latent component, which serves as an indicator of its internal consistency.

The results indicated that all latent constructs were deemed reliable as their Cronbach's alpha values surpassed the threshold of 0.6. Notably, values ranging between 0.7 and 0.8 are considered satisfactory, while those falling within the 0.7 to 0.9 range are deemed acceptable (Hair et al., 2019). Additionally, all latent constructs exhibited loading values exceeding 0.7, which signifies that the number of items remained consistent from the beginning to the end for each construct.

According to the findings presented in Table 3, the AVE (Average Variance Extracted) values exceeded 0.5, as indicated by previous research, and the composite reliability surpassed 0.7 for all constructs (Hair et al., 2019). Consequently, it was determined that the constructs exhibited convergent validity. To assess the discriminant validity of the measures, the Fornell and Larcker approach, as well as the Heterotrait-Monotrait Ratio (HTMT) method, were employed (Hair et al., 2019). In this approach, the square root of the AVE of each latent construct was compared to

**Table 2 Constructs, number of indicators, indicators, and Cronbach's alpha.**

| Construct (Code) | No. of indicators | Indicators | Adopted and modified from | Cronbach's alpha |
|---|---|---|---|---|
| Attitudes (AT) | 5 | AT1 AT2 AT3 AT4 AT5 | Hernández-Ramos et al. (2014) | 0.950 |
| Self-efficacy (SE) | 7 | SE1 SE2 SE3 SE4 SE5 SE6 SE7 | Banoglu et al. (2015) | |
| Digital competence (DC) | 5 | DC1 DC2 DC3 DC4 DC5 | Ghavifekr and Rosdy (2015) | |
| Digital tools utilization (DTU) | | DTU1 DTU2 DTU3 DTU4 DTU5 | Yildirim and Akkuş (2020) | |
| ICT integration (ICTI) | 5 | ICTI1 ICTI2 ICTI3 ICTI4 ICTI5 | Gutiérrez-Martín et al. (2022) | |

**Table 3 Measurement model result.**

| Constructs | Items | Loadings | Cronbach's a | Composite reliability | Average variance extracted |
|---|---|---|---|---|---|
| Attitudes | AT1 | 0.839 | 0.9 | 0.926 | 0.714 |
| | AT2 | 0.86 | | | |
| | AT3 | 0.837 | | | |
| | AT4 | 0.845 | | | |
| | AT5 | 0.843 | | | |
| Self-efficacy | SE1 | 0.802 | 0.898 | 0.92 | 0.621 |
| | SE2 | 0.79 | | | |
| | SE3 | 0.745 | | | |
| | SE4 | 0.786 | | | |
| | SE5 | 0.807 | | | |
| | SE6 | 0.787 | | | |
| | SE7 | 0.797 | | | |
| Digital competence | DC1 | 0.844 | 0.894 | 0.922 | 0.702 |
| | DC2 | 0.837 | | | |
| | DC3 | 0.827 | | | |
| | DC4 | 0.844 | | | |
| Digital tools utilization | DC5 | 0.838 | 0.912 | 0.934 | 0.739 |
| | DTU1 | 0.846 | | | |
| | DTU2 | 0.856 | | | |
| | DTU3 | 0.876 | | | |
| | DTU4 | 0.861 | | | |
| | DTU5 | 0.858 | | | |
| ICT integration | ICTI1 | 0.828 | 0.889 | 0.918 | 0.692 |
| | ICTI2 | 0.821 | | | |
| | ICTI3 | 0.839 | | | |
| | ICTI4 | 0.844 | | | |
| | ICTI5 | 0.825 | | | |

**Table 4 Discriminant validity of the measurement model.**

| | AT | DC | DTU | ICTI | SE |
|---|---|---|---|---|---|
| AT | 0.845 | | | | |
| DC | 0.610 | 0.838 | | | |
| DTU | 0.585 | 0.550 | 0.860 | | |
| ICTI | 0.616 | 0.571 | 0.535 | 0.832 | |
| SE | 0.535 | 0.469 | 0.480 | 0.512 | 0.788 |

**Table 5 Heterotrait-monotrait ratio (HTMT) results.**

| | AT | DC | DTU | ICTI | SE |
|---|---|---|---|---|---|
| AT | | | | | |
| DC | 0.680 | | | | |
| DTU | 0.646 | 0.608 | | | |
| ICTI | 0.689 | 0.640 | 0.594 | | |
| SE | 0.594 | 0.522 | 0.530 | 0.572 | |

the correlations between different latent constructs. Notably, all diagonal values in Tables 4 and 5 were greater than the other correlation values, thus satisfying the requirement for discriminant validity.

**Table 6 Inner VIF for the predictors.**

| | AT | DC | DTU | ICTI | SE |
|---|---|---|---|---|---|
| AT | | 1.401 | 1.823 | 2.008 | |
| DC | | | 1.669 | 1.792 | |
| DTU | | | | 1.736 | |
| ICTI | | | | | |
| SE | 1 | 1.401 | 1.467 | 1.524 | |

**Structural model**. The evaluation of the structural model comprises a series of five steps. The initial step involves testing for multicollinearity and assessing the variance inflation factor (VIF) among all endogenous constructs. In the second step, the t-value and *p*-value are evaluated. The third stage entails examining the Coefficient of Determination ($R^2$), while the fourth step focuses on effect size ($f^2$). Finally, the model's prediction ability is assessed through the fifth step, which involves determining the $Q^2$ value. To begin with, there are no issues of multicollinearity, as all VIF values of predictors in the model are below 5, which is considered satisfactory for evaluating the model (Hair et al., 2019). The researchers employed inner VIF scores since all factors within the model are reflective rather than formative. The

**Table 7 R square, effect sizes ($f^2$), and Q square.**

| | $R^2$ | $f^2$ AT | DC | DTU | ICTI | SE | $Q^2$ |
|---|---|---|---|---|---|---|---|
| AT | 0.286 | | 0.302 | 0.101 | 0.084 | | 0.202 |
| DC | 0.401 | | | 0.074 | 0.053 | | 0.279 |
| DTU | 0.424 | | | | 0.027 | | 0.310 |
| ICTI | 0.482 | | | | | | 0.329 |
| SE | | 0.401 | 0.048 | 0.039 | 0.038 | | |

**Table 8 The results of path analysis.**

| Paths | Effect type | Beta | T-value | Decision |
|---|---|---|---|---|
| AT->DC | Direct effect | 0.503 | 15.189*** | Supported |
| AT->DTU | Direct effect | 0.326 | 8.163*** | Supported |
| AT->ICTI | Direct effect | 0.296 | 7.397*** | Supported |
| AT->DC->ICTI | Indirect effect | | 5.367*** | Supported |
| AT->DTU->ICTI | Indirect effect | | 3.939*** | Supported |
| SE->AT | Direct effect | 0.535 | 17.061*** | Supported |
| SE->DC | Direct effect | 0.200 | 5.474*** | Supported |
| SE->DTU | Direct effect | 0.181 | 4.749*** | Supported |
| SE->ICTI | Direct effect | 0.174 | 5.444*** | Supported |
| SE->AT->ICTI | Indirect effect | | 6.423*** | Supported |
| SE->DC->ICTI | Indirect effect | | 3.904*** | Supported |
| SE->DTU->ICTI | Indirect effect | | 3.229*** | Supported |
| DC->DTU | Direct effect | 0.266 | 7.444*** | Supported |
| DC->ICTI | Direct effect | 0.223 | 5.844*** | Supported |
| DC->DTU->ICTI | Indirect effect | | 3.994*** | Supported |
| DTU->ICTI | Direct effect | 0.156 | 4.579*** | Supported |

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

findings of the inner VIF scores for the model's predictors can be seen in Table 6. Furthermore, in this study, the researchers utilized a bootstrapping sampling technique with 5000 iterations of a subsample to test the structural model. The R square, effect sizes ($f^2$), and Q square are presented in Table 7. In terms of the model's predictive potential, the blindfolding technique was employed, revealing that the model exhibits predictive power, as indicated by the $Q^2$ values of all endogenous constructs exceeding 0, as displayed in Table 7.

The findings of the path analysis are presented in Table 8 and Fig. 2. The results reveal significant relationships between various factors among in-service teachers. First, attitudes of in-service teachers significantly influence their digital competence (AT->DC: $\beta = 0.503$, $p < 0.01$), digital tools utilization (AT->DTU: $\beta = 0.326$, $p < 0.01$), and ICT integration (AT->ICTI: $\beta = 0.296$, $p < 0.01$). Furthermore, attitudes indirectly impact ICT integration through digital competence and digital tools utilization, with significant and positive effects (AT->DC->ICTI, AT->DTU->ICTI: $p < 0.01$). Second, the self-efficacy of in-service teachers significantly influences their attitudes (SE->AT: $\beta = 0.535$, $p < 0.01$), digital competence (SE->DC: $\beta = 0.200$, $p < 0.01$), digital tools utilization (SE->DTU: $\beta = 0.181$, $p < 0.01$), and ICT integration (SE->ICTI: $\beta = 0.174$, $p < 0.01$). Additionally, self-efficacy indirectly influences ICT integration through attitudes, digital competence, and digital tools utilization, with significant and positive effects (SE->AT->ICTI, SE->DC->ICTI, SE->DTU->ICTI: $p < 0.01$). Moreover, in-service teachers' digital competence has a significant impact on their utilization of digital tools (DC->DTU: $\beta = 0.266$, $p < 0.01$) and ICT integration (DC->ICTI: $\beta = 0.223$, $p < 0.01$). Furthermore, digital competence indirectly influences ICT integration through digital tools utilization, with a significant and positive effect (DC->DTU->ICTI: $p < 0.01$). Lastly, in-service teachers' digital tools

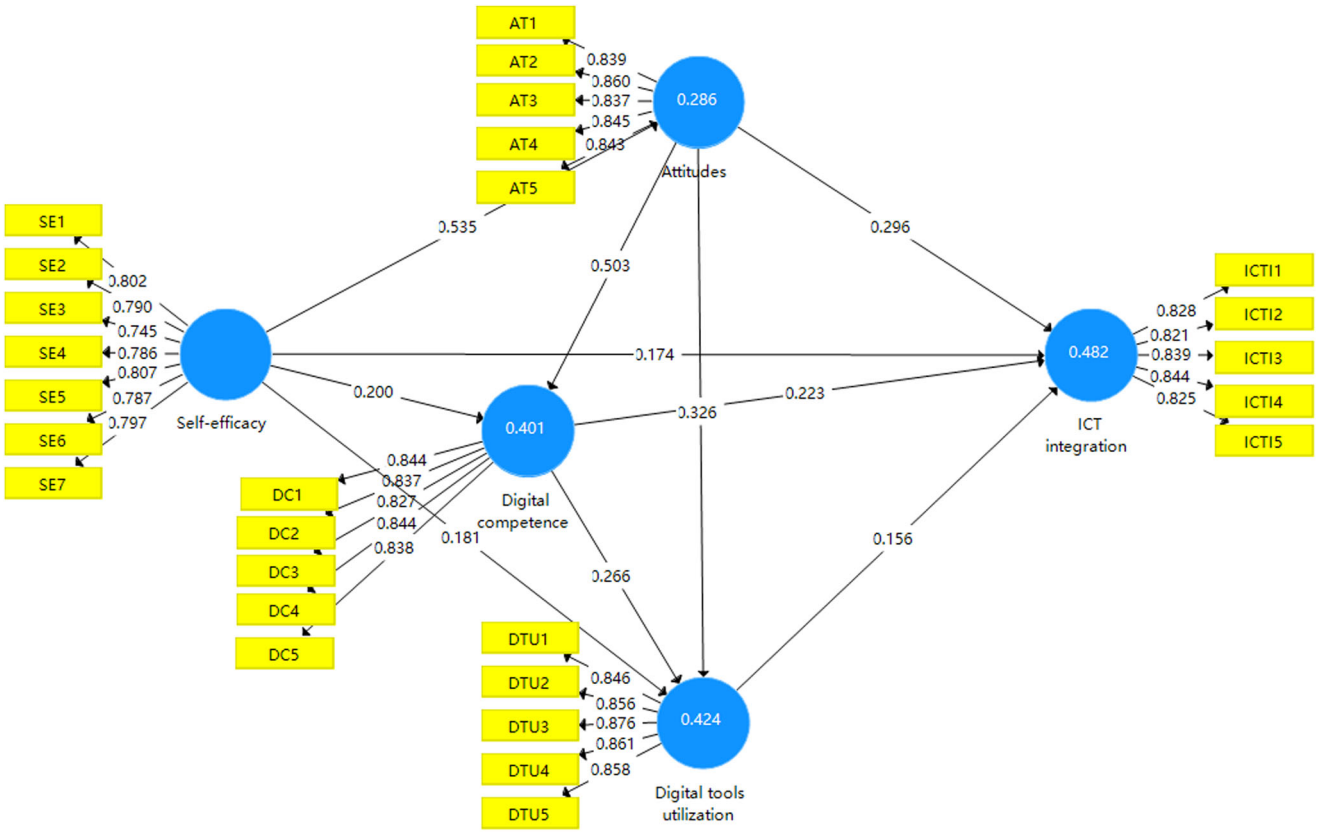


**Fig. 2 The model of factors influencing in-service teachers' ICT integration.** The integration of ICT by in-service instructors was significantly influenced by all four elements (attitudes, self-efficacy, digital competence, and digital tools utilization). At the same time, attitudes, digital competence, and digital tools utilization played a mediating role in the process.

utilization significantly influences ICT integration (DTU->ICTI: $\beta = 0.156$, $p < 0.01$).

To assess the model's in-sample predictive capacity, the researchers conducted a test on the coefficient of determination ($R^2$). In this evaluation, the $R^2$ values for the endogenous constructs were examined, and they are categorized as weak, moderate, or substantial when the $R^2$ value reaches 0.25, 0.50, or 0.75, respectively (Hair et al., 2019). The results, as depicted in Table 7, indicate that attitudes exhibit limited power in the model, while other variables demonstrate moderate power. Effect sizes ($f^2$) were also considered, with values greater than 0.02, 0.15, and 0.35 indicating modest, medium, and large effects, respectively. In Table 7, it can be observed that attitudes ($f^2 = 0.302$) have a strong effect size on digital competence, while self-efficacy ($f^2 = 0.401$) has a notable effect size on attitudes. However, when creating $f^2$ for ICT integration, all four predictors (attitudes, self-efficacy, digital competence, digital tools utilization) yielded small effect sizes. In terms of the model's predictive potential, the blindfolding technique indicated that the proposed model possesses predictive power, as the $Q^2$ values for all endogenous constructs surpass 0, as displayed in Table 7.

**Table 9 Factors influencing in-service teachers' ICT integration by gender.**

| Factor | Groups | *n* | M | SD | SE | df | F | *p* |
|---|---|---|---|---|---|---|---|---|
| AT | Male | 210 | 3.152 | 1.116 | 0.077 | 1 | 4.466 | 0.035 |
| | Female | 475 | 3.339 | 1.042 | 0.048 | | | |
| SE | Male | 210 | 3.102 | 1.089 | 0.075 | 1 | 1.379 | 0.241 |
| | Female | 475 | 3.201 | 0.986 | 0.045 | | | |
| DC | Male | 210 | 3.024 | 1.085 | 0.075 | 1 | 8.503 | 0.004 |
| | Female | 475 | 3.275 | 1.016 | 0.047 | | | |
| DTU | Male | 210 | 3.135 | 1.166 | 0.081 | 1 | 3.568 | 0.059 |
| | Female | 475 | 3.310 | 1.093 | 0.050 | | | |
| ICTI | Male | 210 | 3.427 | 1.044 | 0.072 | 1 | 0.198 | 0.656 |
| | Female | 475 | 3.152 | 1.116 | 0.077 | | | |

**Descriptive findings**. The findings related to research question 2, which focuses on the impact of gender, age, and teaching experience on the ICT integration of in-service teachers, are presented in Tables 9–11 and Figs. 3–5. To investigate whether there are statistically significant differences in instructors' perspectives on ICT usage based on their age and teaching experience, we employed a one-way ANOVA followed by the LSD (least significant difference) post-hoc test. For gender, as it is a binary category, no post-hoc analysis was required. Before conducting the ANOVA, Levene's test was utilized to assess the homogeneity of variance among the cases. The results of Levene's test revealed that the distribution is parametric, indicating that the assumption of normality holds.

Regarding gender, the results indicate that there are no significant differences between teachers' self-efficacy, digital tools utilization, and ICT integration based on their gender ($p > 0.05$). However, there is a significant difference in attitudes and digital competence between male and female in-service teachers ($p > 0.05$). Females tend to have more positive attitudes and higher digital competence compared to males. In terms of age, the findings reveal that there are no significant differences in attitudes and self-efficacy among teachers of different age groups ($p > 0.05$). However, significant differences exist in digital competence, digital tools utilization, and ICT integration based on age ($p < 0.05$). In-service teachers aged 31–35 years exhibit significantly stronger digital abilities, utilize digital tools more effectively, and integrate ICT better than those aged 20–30 years or older than 35 years. Regarding teaching experience, no significant difference was found in the utilization of digital tools among in-service teachers ($p > 0.05$). However, significant differences exist in attitudes, self-efficacy, digital competence, and ICT integration based on teaching experience. Teachers with less than three years of experience demonstrate significantly stronger attitudes, self-efficacy, digital competence, and ICT integration compared to teachers with more than 10 years of experience.

**Table 10 Factors influencing in-service teachers' ICT integration by age.**

| Factor | Groups | *n* | M | SD | SE | df | F | *p* | LSD |
|---|---|---|---|---|---|---|---|---|---|
| AT | 20-30 | 200 | 3.257 | 1.095 | 0.077 | 4 | 1.546 | 0.187 | |
| | 31-35 | 231 | 3.414 | 1.038 | 0.068 | | | | |
| | 36-45 | 157 | 3.162 | 1.060 | 0.085 | | | | |
| | 46-55 | 65 | 3.240 | 1.134 | 0.141 | | | | |
| | >55 | 32 | 3.156 | 0.975 | 0.172 | | | | |
| SE | 20-30 | 200 | 3.219 | 0.938 | 0.066 | 4 | 1.185 | 0.316 | |
| | 31-35 | 231 | 3.228 | 0.948 | 0.062 | | | | |
| | 36-45 | 157 | 3.124 | 1.083 | 0.086 | | | | |
| | 46-55 | 65 | 2.945 | 1.268 | 0.157 | | | | |
| | >55 | 32 | 3.143 | 1.103 | 0.195 | | | | |
| DC | 20-30 | 200 | 3.080 | 1.062 | 0.075 | 4 | 3.624 | 0.006 | 2 > 1,3,5 |
| | 31-35 | 231 | 3.401 | 0.951 | 0.063 | | | | |
| | 36-45 | 157 | 3.121 | 1.023 | 0.082 | | | | |
| | 46-55 | 65 | 3.151 | 1.221 | 0.151 | | | | |
| | >55 | 32 | 2.938 | 1.101 | 0.195 | | | | |
| DTU | 20-30 | 200 | 3.249 | 1.103 | 0.078 | 4 | 3.336 | 0.010 | 2 > 3 |
| | 31-35 | 231 | 3.437 | 1.045 | 0.069 | | | | |
| | 36-45 | 157 | 3.027 | 1.170 | 0.093 | | | | |
| | 46-55 | 65 | 3.258 | 1.180 | 0.146 | | | | |
| | >55 | 32 | 3.119 | 1.167 | 0.206 | | | | |
| ICTI | 20-30 | 200 | 3.259 | 1.085 | 0.077 | 4 | 4.215 | 0.002 | 2 > 1,3,5 |
| | 31-35 | 231 | 3.642 | 0.863 | 0.057 | | | | |
| | 36-45 | 157 | 3.432 | 1.065 | 0.085 | | | | |
| | 46-55 | 65 | 3.523 | 1.107 | 0.137 | | | | |
| | >55 | 32 | 3.263 | 1.079 | 0.191 | | | | |

**Table 11 Factors influencing in-service teachers' ICT integration by teaching experience.**

| Factor | Groups | *n* | M | SD | SE | df | F | *p* | LSD |
|---|---|---|---|---|---|---|---|---|---|
| AT | <3 | 428 | 3.377 | 1.038 | 0.050 | 4 | 3.129 | 0.014 | 1 > 3 |
| | 4–10 | 170 | 3.198 | 1.082 | 0.083 | | | | |
| | 11–20 | 57 | 2.965 | 1.109 | 0.147 | | | | |
| | 21–30 | 16 | 3.163 | 1.286 | 0.322 | | | | |
| | >30 | 14 | 2.814 | 1.068 | 0.286 | | | | |
| SE | <3 | 428 | 3.248 | 1.006 | 0.049 | 4 | 5.186 | 0.000 | 1 > 3,4,5 |
| | 4–10 | 170 | 3.196 | 1.022 | 0.078 | | | | |
| | 11–20 | 57 | 2.862 | 1.012 | 0.134 | | | | |
| | 21–30 | 16 | 2.536 | 1.000 | 0.250 | | | | |
| | >30 | 14 | 2.490 | 0.790 | 0.211 | | | | |
| DC | <3 | 428 | 3.297 | 1.007 | 0.049 | 4 | 4.085 | 0.003 | 1 > 2,3,5 |
| | 4–10 | 170 | 3.108 | 1.052 | 0.081 | | | | |
| | 11–20 | 57 | 2.835 | 1.114 | 0.148 | | | | |
| | 21–30 | 16 | 3.262 | 1.264 | 0.316 | | | | |
| | >30 | 14 | 2.643 | 1.011 | 0.270 | | | | |
| DTU | <3 | 428 | 3.327 | 1.110 | 0.054 | 4 | 1.245 | 0.290 | |
| | 4–10 | 170 | 3.140 | 1.092 | 0.084 | | | | |
| | 11–20 | 57 | 3.126 | 1.204 | 0.160 | | | | |
| | 21–30 | 16 | 3.288 | 1.145 | 0.286 | | | | |
| | >30 | 14 | 3.014 | 1.237 | 0.331 | | | | |
| ICTI | <3 | 428 | 3.516 | 1.000 | 0.048 | 4 | 3.048 | 0.017 | 1 > 3,5 |
| | 4–10 | 170 | 3.436 | 0.997 | 0.076 | | | | |
| | 11–20 | 57 | 3.133 | 1.111 | 0.147 | | | | |
| | 21–30 | 16 | 3.588 | 1.174 | 0.294 | | | | |
| | >30 | 14 | 2.871 | 1.170 | 0.313 | | | | |

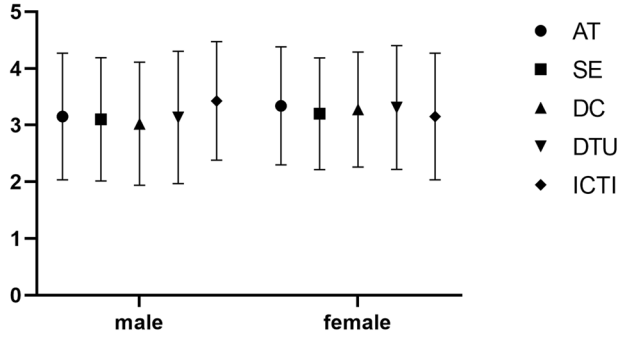


**Fig. 3 The results of one-way ANOVA of gender.** Based on gender, there are no noteworthy distinctions observed in teachers' self-efficacy, digital tools utilization, and ICT integration. However, a notable difference is observed between male and female in-service teachers in terms of attitudes and digital competence.

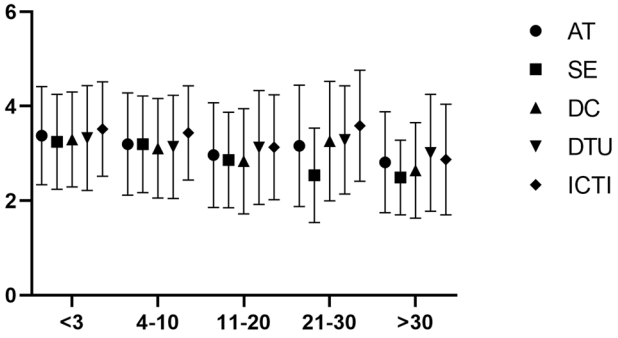


**Fig. 5 The results of one-way ANOVA of teaching experience.** In relation to teaching experience, no noteworthy disparity was observed in the utilization of digital tools among in-service teachers. Nevertheless, significant differences are evident in attitudes, self-efficacy, digital competence, and ICT integration.

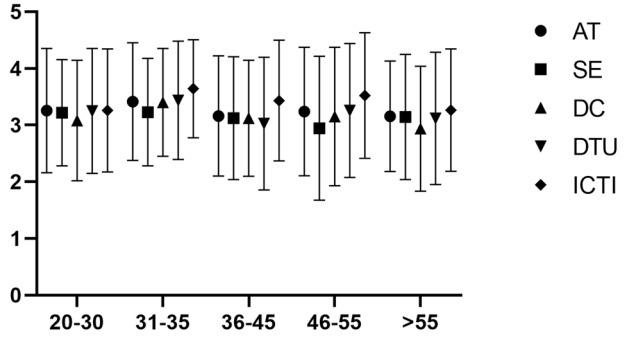


**Fig. 4 The results of one-way ANOVA of age.** Among teachers of varying age groups, no substantial variations are found in attitudes and self-efficacy. Nevertheless, siginicant distinctions are evident in terms of digital competence, digital tools utilization, and ICT integration.

## Discussion

Numerous scholars have conducted extensive research to address educational development challenges, specifically related to the integration of ICT in the education sector. This particular study employed structural equation modeling (SEM) to analyze the factors influencing the integration of ICT among in-service teachers in China. The study adopted a conceptual model that combined TAM3 and WST models to uncover the factors that impact the ICT integration of in-service teachers. Attitudes, self-efficacy, digital competence, and digital tools utilization were identified as key factors to enhance the understanding of the determinants influencing in-service teachers' integration of ICT. Moreover, the findings indicated that the model employed in the study was suitable, as the measures of reliability, convergent validity, Cronbach's alpha, and discriminant validity all yielded satisfactory results. Consequently, all paths were validated, confirming the significant and positive connections between the variables.

The objective of this research was to evaluate the attitudes, self-efficacy, digital competence, and digital tools utilization among teachers currently in service. These factors are considered essential in improving productivity and efficiency in the integration of ICT, addressing the first research question. The extent to which ICT is fully utilized or underutilized in developing countries cannot be definitively determined. Consistent with the findings of Bariu and Chun (2022) Ursavaş et al. (2019), and Verma et al. (2018), this study reveals that teachers' attitudes significantly and positively impact their digital competence, usage of digital tools and ICT integration. The study suggests that teachers' positive attitudes play a significant role in encouraging students to engage with ICT in the classroom, thereby supporting effective teaching. To promote global development, educational institutions in developing nations should encourage teachers to use computers, fostering positive attitudes toward ICT. Furthermore, attitudes demonstrate a critical influence on ICT integration, as evidenced by their higher coefficient value compared to the other three components.

The study's findings also indicate that self-efficacy significantly influences the attitudes, digital competence, digital tools utilization, and ICT integration of teachers currently in service. This suggests that teachers with low self-efficacy may perceive ICT as difficult to use or less useful in their context. These results align with similar studies conducted by Peciuliauskiene et al. (2022) and Yada et al. (2022), which highlight that higher self-efficacy among teachers leads to better attitudes, digital competence, digital tools utilization, and ICT integration. Additionally, the study reveals that teachers' digital competence positively impacts their usage of digital tools and ICT integration. This finding is consistent with the research conducted by Dwiono et al. (2018), Fominykh et al. (2021), and Méndez et al. (2022), which emphasize the need for teachers to enhance their digital skills in teaching. Teachers who possess greater digital competence are more adept at utilizing digital tools and integrating information technology. Therefore, schools and policymakers need to develop reasonable policies that encourage teachers to enhance their digital capabilities, actively engage in digital technology training, improve their attitudes and self-efficacy in using digital technology, and foster the acquisition of digital skills to effectively apply ICT in the classroom teaching and enhance teaching quality. Furthermore, the results confirm that teachers' digital tools utilization has a positive and significant impact on ICT integration. Lavrenova et al. (2020) propose that the introduction of modern digital tools and the application of various network programs and platforms have greatly improved the efficiency of ICT integration. Convenient digital tools serve as the fundamental guarantee for successful ICT teaching, and the robust development of digital tools will further facilitate effective ICT teaching methods.

This research model aims to investigate the variations in factors influencing the integration of ICT among in-service teachers concerning gender, age, and teaching experience, as addressed in research question 2. The findings indicate that gender does not have a significant impact on teachers' self-efficacy, digital tools utilization, and ICT integration, which aligns with the studies conducted by Baroudi and Shaya (2022) and Dolighan and Owen (2021). However, there is a notable difference between in-service teachers' attitudes and digital competence based on gender. In contrast to the findings of Ikwuka et al. (2020) and Semerci and Aydin (2018), females tend to display higher levels of positive attitudes and digital competence compared to males. As the teaching profession is predominantly occupied by women and with China's commitment to gender equality in education, it is plausible that women exhibit stronger attitudes and digital skills. Consequently, there is no significant disparity between men and women in terms of self-efficacy, digital tools utilization, and ICT integration, as China strives for gender equity in education.

The findings indicate that there is no noteworthy distinction between teachers' attitudes and self-efficacy based on their age. However, a significant difference exists in terms of in-service teachers' digital competence, digital tools utilization, and ICT integration, aligning with the conclusions drawn by Şen and Yildiz (2022) and Šabić et al. (2021). Specifically, teachers aged 31–35 years exhibit notably stronger digital skills, greater digital tools utilization, and higher proficiency in integrating ICT compared to individuals aged 20–30 years or above 35 years. Consequently, teachers in the approximate age range of 30 years can be considered the key drivers of digital teaching. When providing training to enhance digital technology skills, it is crucial to prioritize the capacity building of both younger and older teachers.

The findings further revealed that while there is no notable distinction in the utilization of digital tools among in-service teachers, a significant difference exists in terms of their attitudes, self-efficacy, digital competence, and ICT integration based on their teaching experience, corroborating the findings of Baroudi and Shaya (2022) and Kalra (2018). Specifically, teachers with less than three years of teaching experience demonstrate significantly stronger attitudes, self-efficacy, digital competence, and ICT integration compared to those with more than 10 years of experience. It appears that teachers with greater experience may exhibit a decline in their utilization of ICT, potentially due to complacency or a reduced drive to adopt new technologies. Conversely, teachers with less experience, who may be in the early stages of their careers, exhibit a stronger inclination to work and learn, resulting in more efficient cultivation of their digital skills and applications.

## Conclusion

This research introduces an innovative framework that merges the TAM3 and WST models, incorporating elements of ICT integration that impact in-service teachers. Additionally, our model supports a portion of existing research that explores the factors affecting TAM3 and WST models. The objective was to develop a robust framework within a contemporary context, emphasizing the factors that influence the adoption of ICT by in-service teachers in educational institutions, which are recognized as vital contributors to the educational system.

The findings of this study illustrate the interconnected relationship between teachers' attitudes, self-efficacy, digital competencies, and digital tools utilization, all of which have an impact on their integration of ICT. Based on our results, in-service teachers can enhance their effectiveness by optimizing ICT content, collaboration strategies, and communication methods. Teachers recognize that fostering positive attitudes and self-efficacy, developing strong digital skills, and actively employing digital tools are essential for successful ICT integration. Therefore, educational institutions should implement diverse approaches such as seminars, training programs, and other methods to enhance these influential factors and promote the effective use of ICT in teaching.

While this study provides innovative insights into the theoretical and practical aspects impacting the ICT integration of in-service teachers, it is essential to acknowledge its limitations. Primarily, the generalizability of the findings is limited due to the exclusive focus on data from China. Therefore, it is recommended that future research includes data from teachers in diverse countries to ensure broader applicability. Additionally, this study only examined four influencing factors, and the quantitative analysis of these factors had certain limitations. Subsequent

studies could address this gap by conducting a comparative analysis of the factors influencing ICT integration among in-service teachers in different countries.

## Data availability

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

Received: 5 February 2023; Accepted: 16 June 2023;
Published online: 06 July 2023

## References

Aidoo B, Macdonald MA, Vesterinen V-M, Pétursdóttir S, Gísladóttir B (2022) Transforming teaching with ICT using the flipped classroom approach: dealing with COVID-19 pandemic. Educ Sci 12(6):421

Al-dheleai YM, Baki R, Tasir Z, Al-rahmi WM (2019) What hinders the use of ICT among academic staff at Yemen's public universities? Int J Humanit Innov 2(1):7–12

Alhassan R (2017) Exploring the relationship between web 2.0 tools self-efficacy and teachers' use of these tools in their teaching. J Educ Learn 6(4):217

Al-Maroof RS, Salloum SA (2020) An integrated model of continuous intention to use of Google Classroom. In: Al-Emran M, Shaalan K, Hassanien A (eds) Recent advances in intelligent systems and smart applications. Studies in systems, decision and control, Springer, Cham, pp 311–335. https://doi.org/10.1007/978-3-030-47411-9_18

Amhag L, Hellström L, Stigmar M (2019) Teacher educators' use of digital tools and needs for digital competence in higher education. J Digit Learn Teach Educ 35(4):203–220

Antonietti C, Cattaneo A, Amenduni F (2022) Can teachers' digital competence influence technology acceptance in vocational education? Comput Hum Behav 132:107266

Arhin D, Kwakye K, Quaynor LQ, Boakye RO, Yeboah JA (2022) Influence of teachers' self-efficacy and attitude towards the integration of ICT into teaching and learning at the basic school level. Am J Educ Pract 6(1):36–45

Backfisch I, Lachner A, Stürmer K, Scheiter K (2021) Variability of teachers' technology integration in the classroom: a matter of utility! Comput Educ 166:104159

Banoglu K, Vanderlinde R, Yildiz R (2015) Professional self-efficacy scale for information and computer technology teachers: validity and reliability study. Anthropol 20(1–2):22–32

Bariu TN, Chun X (2022) Influence of teachers' attitude on ICT implementation in Kenyan universities. Cogent Educ 9(1). https://doi.org/10.1080/2331186x.2022.2107294

Baroudi S, Shaya N (2022) Exploring predictors of teachers' self-efficacy for online teaching in the Arab World Amid COVID-19. Educ Inf Technol 27(6):8093–8110

Busse J, Busse R, Schumann M (2022) Does technology matter? How digital self-efficacy affects the relationship between ICT exposure and job dissatisfaction. In: Proceedings of the 55th Annual Hawaii International Conference on System Sciences. University of Hawaii at Manoa, Honolulu. https://doi.org/10.24251/hicss.2022.759

Cabero-Almenara J, Guillén-Gámez FD, Ruiz-Palmero J, Palacios-Rodríguez A (2021) Digital competence of higher education professor according to DigCompEdu. Statistical research methods with ANOVA between fields of knowledge in different age ranges. Educ Inf Technol 26(4):4691–4708

Christensen R, Knezek G (2008) Self-report measures and findings for Information Technology Attitudes and competencies. In: Voogt J, Knezek G (eds) International Handbook of Information Technology in Primary and Secondary Education, vol 20. Springer, Boston, pp 349–365

Coban O, Atasoy R (2019) An examination of relationship between teachers' self-efficacy perception on ICT and their attitude towards ICT usage in the classroom. Cypriot J Educ Sci 14(1):136–145

Dolighan T, Owen M (2021) Teacher efficacy for online teaching during the COVID-19 pandemic. Brock Educ J 30(1):95

Dwiono R, Rochsantiningsih D, Suparno S (2018) Investigating the integration level of Information and Communication Technology (ICT) in the English Language Teaching. Int J Lang Teach Educ 2(3):259–274

Fearnley MR, Amora JT (2020) Learning management system adoption in higher education using the Extended Technology Acceptance Model. IAFOR J Educ 8(2):89–106

Fominykh M, Shikhova E, Soule MV, Perifanou M, Zhukova D (2021) Digital competence assessment survey for language teachers. In: Zaphiris P, Ioannou A (eds) Learning and collaboration technologies: new challenges and learning experiences. Springer, Cham, pp 264–282. https://doi.org/10.1007/978-3-030-77889-7_18

Ghavifekr S, Rosdy WA (2015) Teaching and learning with technology: effectiveness of ICT integration in schools. Int J Res Educ Sci 1(2):175

Gutiérrez-Martín A, Pinedo-González R, Gil-Puente C (2022) ICT and media competencies of teachers. Convergence towards an integrated MIL-ICT model. Comunicar 30(70):21–33

Hair JF, Risher JJ, Sarstedt M, Ringle CM (2019) When to use and how to report the results of PLS-SEM. European Business Review 31(1):2–24

Hatlevik IKR, Hatlevik OE (2018) Examining the relationship between teachers' ICT self-efficacy for educational purposes, collegial collaboration, lack of facilitation and the use of ICT in teaching practice. Front Psychol 9:935

Hernández-Ramos JP, Martínez-Abad F, García Peñalvo FJ, Esperanza Herrera García M, Rodríguez-Conde MJ (2014) Teachers' attitude regarding the use of ICT. A factor reliability and validity study. Comput Hum Behav 31:509–516

Ikwuka OI, Onyali LC, Olugbemi OP, Etodike CE, Igbokwe IC, Adigwe EJ (2020) Teachers' attitude towards the use of ICT for quality instructional delivery in Onitsha North Secondary Schools, Anambra State, Nigeria. Int J Acad Res Progress Educ Dev 9(3):1–11

Kalra R (2018) Experienced and novice teachers' awareness and attitudes towards ICT in language classroom: a study conducted in a Thai context. Arab World Engl J 4(4):125–131

Kumar V, Verma P, Mittal A, Tuesta Panduro JA, Singh S, Paliwal M, Sharma NK (2022) Adoption of ICTs as an emergent business strategy during and following COVID-19 crisis: evidence from Indian MSMEs. Benchmarking: Int J. https://doi.org/10.1108/bij-11-2021-0685

Lai X, Nie C, Huang S, Yao Y, Li Y, Dai X, Wang Y (2022) Classes of problematic smartphone use and information and Communication Technology (ICT) self-efficacy. J Appl Dev Psychol 83:101481

Lavrenova M, Lalak NV, Molnar TI (2020) Preparation of future teachers for use of ICT in primary school. Revista Romaneasca Pentru Educatie Multidimensionala 12(1Sup1):185–195

LeTendre G (2022) Globalization and the impact of ICT on teacher's work and professional status. In: The Palgrave Handbook of Teacher Education Research, Palgrave Macmillan, Cham, pp 1–22. https://doi.org/10.1007/978-3-030-59533-3_83-1

Li X, Shaikh PA, Ullah S (2022) Exploring the potential role of higher education and ICT in China on green growth. Environ Sci Pollut Res Int 29(43):64560–64567

Liao CH, Chiang C-T, Chen I-C, Parker KR (2022) Exploring the relationship between computational thinking and learning satisfaction for non-STEM college students. Int J Educ Technol High Educ 19(1):43

Lu D, Xie Y-N (2022) Critical thinking cultivation in TESOL with ICT Tools: a systematic review. Comput Assist Lang Learn, 1–21. https://doi.org/10.1080/09588221.2022.2033788

Lucas M, Bem-Haja P, Siddiq F, Moreira A, Redecker C (2021) The relation between in-service teachers' digital competence and personal and contextual factors: what matters most. Comput Educ 160:104052

Lukas BA, Yunus MM (2021) ESL teachers' challenges in implementing e-learning during COVID-19. Int J Learn Teaching Educ Res 20(2):330–348

Ma M, Chen J, Zheng P, Wu Y (2019) Factors affecting EFL teachers' affordance transfer of ICT resources in China. Interact Learn Environ 30(6):1044–1059

Mannila L, Nordén L-Å, Pears A (2018) Digital competence, teacher self-efficacy and training needs. In: Proceedings of the 2018 ACM Conference on International Computing Education Research, Association for Computing Machinery, New York, pp 78–85. https://doi.org/10.1145/3230977.3230993

Méndez VG, Suelves DM, Méndez CG, Mas JA (2022) Future teachers facing the use of technology for inclusion: a view from the digital competence. Educ Inf Technol. https://doi.org/10.1007/s10639-022-11105-5

Nuhu KM, Onojah AO (2021) Effect of webinar multimedia platform on students' academic performance in selected Educational Technology Concepts in University of Ilorin. Indonesian J Multidisciplinary Res 2(1):9–20. https://doi.org/10.17509/ijomr.v2i1.38622

Ogalo MO, Omulando C, Barasa P (2022) Assessment of teachers' technological and pedagogical knowledge of integrating ICT in teaching English in secondary schools in Nairobi County, Kenya. Scholars J Arts Humanit Soc Sci 10(1):9–23

Ogodo JA, Simon M, Morris D, Akubo M (2021) Examining K-12 teachers' digital competency and technology self-efficacy during COVID-19 pandemic. J High Educ Theory Pract 21(11). https://doi.org/10.33423/jhetp.v21i11.4660

Peciuliauskiene P, Tamoliune G, Trepule E (2022) Exploring the roles of Information Search and Information Evaluation Literacy and pre-service teachers' ICT self-efficacy in teaching. Int J Educ Technol High Educ 19(1). https://doi.org/10.1186/s41239-022-00339-5

Pham ST, Sampson PM (2022) The development of artificial intelligence in education: a review in context. J Comput Assist Learn 38(5):1408–1421
Pokhrel S, Chhetri R (2021) A literature review on impact of COVID-19 pandemic on teaching and learning. High Educ Future 8(1):133–141
Pozas M, Letzel V (2021) "Do you think you have what it takes?"—exploring predictors of pre-service teachers' prospective ICT use. Technol Knowl Learn 28:823–841
Šabić J, Baranović B, Rogošić S (2021) Teachers' self-efficacy for using information and communication technology: the interaction effect of gender and age. Inform Educ 21:353–373
Semerci A, Aydın MK (2018) Examining high school teachers' attitudes towards ICT use in education. Int J Progress Educ 14(2):93–105
Şen N, Yildiz Durak H (2022) Examining the relationships between English teachers' lifelong learning tendencies with professional competencies and technology integrating self-efficacy. Educ Inf Technol 27(5):5953–5988
Seufert S, Guggemos J, Sailer M (2021) Technology-related knowledge, skills, and attitudes of pre- and in-service teachers: the current situation and emerging trends. Comput Hum Behav 115:106552
Štemberger T, Čotar Konrad S (2021) Attitudes towards using digital technologies in education as an important factor in developing digital competence: the case of Slovenian student teachers. Int J Emerg Technol Learn 16(14):83
Tsegay SM, Ashraf MA, Perveen S, Zegergish MZ (2022) Online teaching during COVID-19 pandemic: teachers' experiences from a Chinese University. Sustainability 14(1):568
Ursavaş ÖF, Yalçın Y, Bakır E (2019) 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):2501–2519
Venkatesh V, Bala H (2008) Technology acceptance model 3 and a research agenda on interventions. Decis Sci 39(2):273–315
Verma S, Bhattacharyya SS, Kumar S (2018) An extension of the technology acceptance model in the Big Data Analytics System Implementation Environment. Inf Process Manag 54(5):791–806
Wang Q, Zhao G (2021) 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):2319–2339
Yada A, Leskinen M, Savolainen H, Schwab S (2022) Meta-analysis of the relationship between teachers' self-efficacy and attitudes toward inclusive education. Teaching and Teacher Education 109:103521
Yildirim B, Akkuş A (2020) Developing a scale to assess teachers' perceptions towards using web 2.0 tools in lectures (TPUWL scale). Participatory Educational Research 7(3):124–138
Zhou L, Wu S, Zhou M, Li F (2020) '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. SSRN Electron J 4(2):501–519

## Author contributions

RP: writing—original draft preparation; RAR: writing—review and editing; SHH: supervision.

## Competing interests

The authors declare no competing interests.

## Ethical approval

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

## Informed consent

The author has informed participants of the purpose of the research and explained to them the way the data will be used. Therefore, informed consent was obtained from all participants and/or their legal guardians for participation in the study.

## Additional information

**Supplementary information** The online version contains supplementary material available at https://doi.org/10.1057/s41599-023-01871-z.

**Correspondence** and requests for materials should be addressed to Rafiza Abdul Razak.

**Reprints and permission information** is available at http://www.nature.com/reprints

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.