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Factors influencing high school teachers' use of ICT in teaching mathematics: Insights from Northern Vietnam

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ABSTRACT

This paper investigates the factors influencing the extent of information and communication technology (ICT) usage in teaching mathematics at high schools. Using exploratory factor analysis and multivariate linear regression analysis on survey data from 204 Vietnamese teachers, the study identifies three main factors affecting teachers' use of ICT: ICT skills, motivation, and access to ICT tools at school. Among these, ICT skills have the most significant impact. Additionally, the study reveals no significant difference in the extent of ICT usage among teachers from different regions or with varying levels of experience. However, male teachers tend to use ICT more than female teachers, and teachers with 1 to 5 years of experience exhibit the highest level of ICT usage in their classroom. The research results provide a scientific basis for proposing solutions to enhance teachers' ICT application skills, thereby improving the quality of mathematics teaching in the current digital transformation context.

Keywords: ICT usage, ICT skills, teaching mathematics, high school teachers, educational innovation

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INTRODUCTION

The application of information and communication technology (ICT), in teaching generally, and in mathematics teaching particularly, has attracted the attention of many researchers. Studies have explored both tools and human factors to understand ICT integration. Some studies focus on introducing and evaluating the effectiveness of using ICT tools and applications as teaching aids. Others examine human factors in the integration of ICT into teaching. Regarding tools, several research works, such as those by Lai (2006), Lim et al. (2010), Trung et al. (2011), and Duc (2017b), have examined the role of multimedia and software as teaching aids, emphasizing their contribution to engaging and enhancing students' learning experiences. On the other hand, human factors such as attitudes, experience, ICT skills, and confidence have been identified as critical elements influencing ICT integration.

The study by Trung et al. (2011) asserts that teachers need confidence and proficiency to integrate ICT into their teaching. While Hinojo-Lucena et al. (2019) indicates that factors such as digital competence, attitude, and confidence significantly impact teachers' teachers' ICT usage in teaching. Agyei and Voogt (2011) introduced the Will-Skill-Tool model, highlighting the interplay between teachers' attitudes, skills, and access to ICT resources in effective integration. Similarly, infrastructural limitations, professional development gaps, and institutional support are recurrent challenges, as pointed out by Ikwuka et al. (2020) and Peng et al. (2023).

Trujillo-Torres et al. (2020) shows that self-perception of ICT competence and the level of support from schools can enhance teachers' motivation to increase ICT usage in the classroom. Similarly, attitudes, perceptions, gender, and experience of mathematics teachers are factors influencing their use of ICT in teaching. Using the PLS-SEM model, Sawyerr and Agyei (2023) demonstrate a significant positive correlation between attitudes, skills, tools, and teachers' use of ICT in teaching, herein tools (access to ICT tools and facilities) being the strongest predictor of ICT usage in teaching.

In Vietnam, studies have shown the relationship between teachers' perceptions, skills, and access to ICT and the extent of ICT usage in teaching. However, the number of studies that specifically analyze the impact of each factor on the extent of ICT usage in teaching, particularly in mathematics, remains limited. This highlights the need for research to delve deeper into these aspects. Stemming from this practical situation, this paper focuses on exploring the factors influencing the extent of ICT usage by high school teachers in teaching mathematics. The research results are expected to provide a scientific and practical basis for proposing effective solutions, thereby enhancing teachers' ICT application capacity and improving the quality of mathematics teaching in the current digital transformation context.

LITERATURE REVIEW

Application of ICT in Mathematics Teaching

In the context of the rapid digital transformation of education, the application of ICT in mathematics teaching is becoming increasingly essential. ICT is considered an effective tool that helps teachers innovate their teaching methods and supports students in effectively acquiring knowledge. (Trujillo-Torres et al., 2020) indicates that ICT not only enhances the visualization in learning mathematics but also motivates and improves students' problem-solving abilities. Mathematics learning software, simulation software, and digital learning platforms allow students to interact, model, and deeply understand abstract mathematical concepts. These technologies bring significant advantages, such as fostering interactivity and personalization in learning.

Research by Dhol et al. (2023) emphasizes that ICT provides a wide range of tools and applications that can be used to improve the quality of mathematics education. These tools can be divided into four groups: dynamic geometry software, algebra and calculation software, online learning platforms, simulation software, and educational games. Dynamic geometry software creates an interactive and intuitive learning environment by allowing students to explore geometric properties through direct manipulation of drawings, such as moving points, changing dimensions, and observing the changes in other elements. Algebra and calculation software support solving complex algebraic problems, calculations, and representing functions, helping students focus on understanding the essence of problems instead of spending time on manual calculations. Online learning platforms provide learning resources, allowing students to study at their own pace and receive feedback, thus personalizing learning. Some platforms integrate social features, creating an interactive and collaborative learning environment. Simulation software can help students understand abstract concepts by visualizing them, while games can enhance learning motivation and develop problem-solving skills.

In that context, integrating ICT into mathematics teaching has become an essential component of modern education, revolutionizing both teaching methods and learning experiences. Duc (2017a) focuses on the application of GeoGebra to support the teaching and learning of spatial geometry through the method of unfolding shapes, which means "opening" a three-dimensional shape into a two-dimensional shape by cutting along certain edges. This method helps students easily visualize the structure of spatial shapes and apply planar geometry knowledge to solve problems. In the article, the author emphasizes the advantages of GeoGebra and its implementation in supporting the unfolding method. As a dynamic mathematics software, GeoGebra is particularly noteworthy in its application to teaching spatial geometry. It allows students to interact with the unfolding in an intuitive way, such as moving points, changing dimensions, and observing the transformations of the shapes. Students can interact with the unfolding on GeoGebra, such as moving points, changing dimensions, and observing the changes in the shapes. This method helps students visualize and understand problems in an intuitive and lively way, thereby enhancing the effectiveness of teaching and learning mathematics, especially in spatial geometry.

Trung and Manh (2019) studied the application of ICT to enhance the effectiveness of teaching and learning statistics at the high school level, especially through practical connections. According to the authors, the reasonable and effective use of ICT will help students approach their learning contents more easily and interestingly, as seen in the role of ICT in data collection and processing, data visualization, simulation, prediction, and enhancing interactivity and interest in learning.

From a broader perspective, Chapai (2023) has pointed out the potential and challenges of integrating ICT into mathematics teaching and learning. Accordingly, ICT allows teachers to visualize mathematical concepts and relationships vividly; create an interactive learning environment that encourages students to participate actively; support personalized teaching; and provide students opportunities to access rich resources, develop problem-solving and logical thinking skills. However, the effectiveness of integrating ICT into teaching depends greatly on objective factors such as ICT infrastructure, skills, and support from schools.

While ICT holds immense potential for transforming mathematics education, its application is influenced by various factors, particularly those related to teachers. Research consistently highlights that teachers' attitudes, beliefs, motivation, and ICT skills are decisive in ensuring the successful integration of technology into teaching. However, challenges such as limited resources, insufficient professional development opportunities, and the risk of over-reliance on ICT, which may diminish direct teacher-student interaction, underscore the need for balanced and thoughtful implementation.

Factors Influencing the Extent of ICT Usage in Teaching

In 2018, UNESCO published the ICT Competency Framework for Teachers (ICT-CFT). Corresponding to three successive stages of teacher development, ICT-CFT proposes three different levels, including: knowledge acquisition, knowledge deepening, and knowledge creation. Each level is divided into six aspects: understanding ICT in education, curriculum and assessment, pedagogy, application of digital skills, organization and administration, and teacher professional learning (UNESCO, 2018). We consider this an important scientific basis for identifying factors influencing ICT usage in mathematics teaching at the high school level.

Identifying factors influencing the use of ICT in teaching has been the focus of many researchers. Isleem (2003) identified the fundamental factors and the extent of ICT use in teaching by educational technology teachers, including: proficiency, access opportunities, attitude, support, and personal characteristics. Based on the Unified Theory of Acceptance and Use of Technology (UTAUT), factors influencing ICT application include performance expectancy, effort expectancy, social influence, facilitating conditions, and moderating factors (age, gender, experience, and voluntariness of use) (Venkatesh et al., 2003). The study by the Western Australia Department of Education and Training (2006) pointed out that ICT competency, school ICT resources, teacher attitude and motivation, policies, and leadership support are the main factors influencing the extent of ICT usage. The study by Peeraer and Petegem (2010) found factors affecting the use of ICT in pedagogical universities in Vietnam, including access opportunities to computers, extent of computer use, ICT skills, ICT confidence of faculty, and personal characteristics (including attitude towards ICT and perceptions of students' learning). Al-Zaidiyeen et al. (2010) identified the main factors influencing ICT use in teaching, including: technological infrastructure, teachers' professional development, support from managers, educational planning and policies, and teachers' acceptance and attitude.

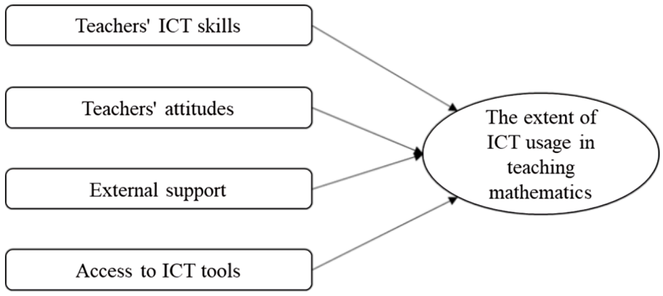

Figure 1. Proposed model (Source: Authors' own elaboration, 2025)

The Will-Skill-Tool (WST) model, developed by Christensen and Knezek (2001, 2008), is a model used to predict and explain the integration of ICT in teaching. The WST model is based on the hypothesis that will, skill, and tool are essential factors for successful ICT integration in teaching. In other words, ICT integration in teaching is a function of internal factors (i.e., will and skill) and external factors (i.e., tool). High integration levels are likely to occur in individuals who are willing to use (will), equipped with ICT skills (skill), and provided with devices and infrastructure (tool). The WST model has been used in many studies to predict and explain the integration of ICT by teachers at different levels, regardless of the teaching field, grade level, type of teaching, or geographic region.

RESEARCH MODEL

Based on the studies presented, factors influencing the usage of ICT in teaching are categorized according to different approaches and use diverse terms. Generally, these factors revolve around individual attitudes, technological competence, external support, and ability to access necessary tools. In this study, we construct a research model with four main factors, specifically

(1) teachers' ICT skills,

(2) teachers' attitudes,

(3) external support (support from school and colleagues), and

(4) access to ICT tools.

The research model is illustrated as in **Figure 1**.

According to the research model, the hypotheses are proposed as follows:

H1: Teachers' ICT skills positively impact the extent of ICT usage in teaching mathematics.

H2: Teachers' attitudes positively impact the extent of ICT usage in teaching mathematics.

H3: Support positively impacts the extent of ICT usage in teaching mathematics.

H4: Access positively impacts the extent of ICT usage in teaching mathematics.

RESEARCH METHODOLOGY

Instrument

Quantitative research methods were employed to ascertain the extent of ICT usage in high school mathematics teaching and the influencing factors. The questionnaire designed for this study comprises two sections: The first section, containing 5 questions, gathers personal information of the respondents (including name, gender, educational background, years of teaching, and school location). The second section consists of 26 questions aimed at collecting information on the extent of ICT usage in mathematics teaching with four influencing factors. Each question is rated on a 5-point Likert scale.

1. Teachers' ICT skills (skill-SK) are evaluated based on their ability to handle basic technical issues with computers, search for and collect necessary information from the internet; utilize software and tools that support classroom mathematics teaching (e.g., Sketchpad, GeoGebra, Cabri Geometry, Desmos, Fathom, TinkerPlots, CODAP, etc.) and use software and tools that support online mathematics teaching (e.g., Mindmap, Edmodo, Padlet, Quizzi, Kahoot!, etc.).
2. Teachers' attitudes (attitude-AT) encompass questions about teachers' interest, perceptions of the necessity, and advantages of ICT in the teaching process.
3. External support (support-SU) is assessed through the support from management bodies and colleagues for the use of ICT in teaching.
4. Accessibility to ICT tools (access-AC) is indicated by the ease of access and use of ICT devices such as computers, projectors, and internet access.
5. Extent of ICT usage (usage-US) is determined by the frequency of using common technological tools in mathematics teaching, such as presentation software, software supporting the teaching of algebra and calculus, geometry, statistics and probability, online classroom management software, and platforms that support online learning, giving assignments, and conducting assessment.

Validity and Reliability

Cronbach's alpha coefficient was calculated to determine the internal consistency of the questions in the scale. The analysis results from **Table 1** indicate that all components in the study have Cronbach's alpha values > 0.7. This demonstrates that the scales used in the research meet the requirements for internal reliability, with questions within each scale showing strong correlations and consistently measuring the same concept.

Table 1. Reliability testing results of measurement scales

No	Factor	Number of observed variables	Cronbach's alpha	Smallest item-total correlation
1	Teachers' ICT skills (SK)	5	.855	.593
2	Teachers' attitudes (AT)	6	.931	.771
3	External support (SU)	4	.898	.756
4	Accessibility to ICT tools (AC)	5	.795	.507
5	Extent of ICT usage (US)	6	.881	.422

Table 2. Survey participants

Characteristics		Quantity	Percentage (%)
Gender	Female	139	68.1
	Male	65	31.9
Education background	Bachelor's degree	117	57.4
	Master's degree	87	42.6
Years of teaching	1–5	20	9.8
	6–10	22	10.8
	11–15	53	26.0
	16–20	41	20.1
	Over 20	68	33.3
School location	Urban	87	42.6
	Rural	81	39.7
	Mountainous	36	17.6

Participants

To ensure an adequate sample size for the planned statistical analyses, particularly exploratory factor analysis (EFA) and multiple linear regression, established guidelines were consulted. According to Hair et al. (2014), while a minimum sample size of 50 is required for EFA, a sample size of 100 or more is preferable, and the ratio of observations to variables should ideally be at least 5:1. Given that this study initially anticipated up to 26 analysis variables (items in the scales), a minimum sample size of $26 \times 5 = 130$ responses was targeted for EFA. Furthermore, for multiple linear regression analysis, Green (1991) suggested the rule of thumb $n \geq 50 + 8n$, where n is the minimum required sample size and p is the number of independent variables. With 4 potential independent variables in the initial model, this would require $n \geq 50 + 8.4 = 82$. Therefore, aiming for a sample size above 130 would satisfy the requirements for both EFA and regression analyses.

The data were collected through an online questionnaire (using Google Form) administered between September 2024 and October 2024. The sampling method employed was a two-stage process involving cluster sampling followed by simple random sampling. First, the provinces and centrally-run cities in Northern Vietnam were defined as the primary sampling units (clusters). From the list of all provinces/cities in this region, 14 were randomly selected. Second, within each selected province/city, lists of high school mathematics teachers were obtained from the respective departments of education and training (DOETs). Using these lists as sampling frames, simple random sampling was applied with the aim of selecting 18 teachers from each cluster. This process resulted in a final achieved sample of 204 high school mathematics teachers who completed the questionnaire. This achieved sample size (N = 204) is comfortably above the minimum threshold of 130 established as necessary for both EFA and regression analyses (**Table 2**).

Among the respondents, there were 65 males (accounting for 31.9%) and 139 females (accounting for 68.1%). The higher number of females is due to the nature of the teaching profession, which generally has a larger proportion of female teachers than male teachers. Regarding educational background, there were 117 university graduates (57.4%) and 87 master's degree holders (42.6%). Respondents' years of teaching are fairly evenly distributed across groups. In terms of school location, the majority work in urban areas (42.6%), followed by rural areas (39.7%) and mountainous regions (17.6%).

Table 3. KMO and Bartlett's test for ICT usage measurement

KMO measure of sampling adequacy		.817
Bartlett's test of sphericity	Approximate Chi-square	760.859
	df	15
	Significance	.000

Data Analysis

Following data collection stage, the collected data was cleaned and analyzed with the aid of SPSS 20.0 software. The techniques employed include:

1. Descriptive statistics: Describing the characteristics of the research sample according to the personal information questions of the teachers.
2. Reliability testing of measurement scales (Cronbach's alpha): Assessing the reliability of the scales using Cronbach's alpha coefficient and eliminating unsuitable variables. Variables with a correlation coefficient less than 0.3 will be excluded. Scales with Cronbach's alpha coefficient greater than 0.6 are considered usable (Peterson, 1994).
3. EFA: Analyzing how factors influence the extent of ICT usage in mathematics teaching. EFA reduces many correlated variables into representative factors. Using Kaiser-Meyer-Olkin (KMO) and Bartlett tests to measure the suitability of the survey sample. Factor analysis is significant when KMO value > 0.5 and sig value < 0.05 (Hair et al., 2014); Factor loadings must be > 0.5 (Gerbing & Anderson, 1988); if an observed variable loads onto two factors, the difference between the loadings must be > 0.3, and the variable is included in the factor it loads highest on, provided it meets the factor loading > 0.5 condition.
4. Multiple linear regression analysis: Identifying the linear regression coefficients of the factors impacting the extent of ICT usage in teaching mathematics.
5. Independent-samples t-test and one-way ANOVA: Statistical tests are conducted to compare the extent of ICT usage in mathematics teaching according to gender, educational background, years of teaching, and school location.

RESEARCH RESULTS

Exploratory Factor Analysis

Factor analysis of ICT Usage items

An EFA was conducted on the 6 items designed to measure the extent of ICT usage in mathematics teaching (the intended dependent variable for subsequent regression analysis). The KMO value of 0.817 satisfies the condition 0.5 < KMO < 1, meaning that EFA is appropriate for the data. Bartlett's test has a sig. value of 0.000, which is less than 0.05, indicating that the observed variables are linearly correlated with the representative factor (**Table 3**).

The extracted variance is 62.881% (which is greater than 50%). The Eigenvalue is greater than 1, and all factor loadings of the observed variables are greater than 0.5 (**Table 4**).

Table 4. Factor matrix for the ICT usage scale items

	Factor
	1
US2	.871
US3	.868
US4	.849
US5	.810
US6	.772
US1	.535

Table 5. KMO and Bartlett's test for the influencing factor items

KMO measure of sampling adequacy		.926
Bartlett's test of sphericity	Approximate Chi-square	2,834.278
	df	190
	Significance	.000

Table 6. Rotated factor matrix for the influencing factor items

	Factors			
	1	2	3	4
SU1	.849			
AT5	.834			
AT3	.827			
AT4	.808			
AT1	.805			
SU2	.792			
AT6	.786			
AT2	.780			
SU4	.752			
SU3	.649			
SK4		.817		
SK1		.795		
SK5		.762		
SK3		.751		
SK2		.676		
AC4			.844	
AC5			.754	
AC2			.729	
AC3				.769
AC1				.733

Factor analysis of predictor items

A separate EFA was performed on the initial 20 items measuring the factors potentially influencing ICT usage (intended as independent variables in the regression model), namely: ICT skills, attitudes, external support, and accessibility to ICT tools. The KMO value of 0.926 is very high, satisfying the condition 0.5 < KMO < 1. Bartlett's test has a sig. value of 0.000 < 0.05, indicating that the observed variables are linearly correlated with the representative factor (**Table 5**).

Table 6 describes the results of EFA at the Eigenvalue level of 1 using the factor extraction method with Varimax rotation, which extracted 4 factors from 20 observed variables. The cumulative percentage value of component 4 = 71.417 (the total variance extracted by the factors) indicates that the first 4 factors explain 71.417% of the data variance. The factor loadings of the variables are all satisfactory (the smallest is 0.649).

Adjusted Research Model

According to the initial research model, the scale of factors affecting the extent of ICT usage in mathematics teaching consists of 20 observed variables belonging to 4 factors. The EFA results indicate that these 20 observed variables are divided into 4 factors, which differ from the initial ones (**Table 6**). The **Skill** factor remains unchanged, while the **Access** factor splits into two: **AccessS** and **AccessH**, which consist of observed variables related to the accessibility and usage of devices at school and at home, respectively. The initial factors **Attitude** and **Support**, consisting of 10 observed variables, were combined into a new factor, namely **Motivation**, which includes teachers' attitudes toward the necessity, advantages, and positive impacts of ICT in teaching and teachers' perceptions of support from management bodies and colleagues for using ICT in teaching. Thus, it encompasses two aspects reflecting teachers' motivation for using ICT: intrinsic and extrinsic motivation. When teachers recognize the importance of ICT and receive stakeholders' support and assistance, they are highly motivated to use ICT in their teaching, thereby enhancing educational quality.

The results of the reliability testing for the new factors are presented in **Table 7**.

All three new factors have Cronbach's alpha values greater than 0.7, with Motivation factor having a very high Cronbach's alpha of 0.95. The smallest item-total correlation among the observed variables is 0.589, which satisfies the condition of being greater than 0.3. This indicates that the variables within the three new factors are highly consistent.

Table 7. Results of reliability testing for the new factors

Components	Cronbach's alpha	Items	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
AccessS	.800	AC2	7.04	3.126	.645	.731
		AC4	7.23	2.717	.612	.772
AccessH	.737	AC5	6.90	2.911	.690	.681
		AC1	4.29	.522	.589	
Motivation	.950	AC3	3.90	.690	.589	
		AT1	37.75	31.482	.783	.944
		AT2	37.87	31.751	.743	.946
		AT3	37.60	31.787	.829	.943
		AT4	37.52	32.300	.815	.944
		AT5	37.71	31.024	.818	.943
		AT6	37.85	30.816	.801	.944
		SU1	37.64	31.710	.833	.942
		SU2	37.72	31.377	.775	.945
		SU3	37.81	31.870	.708	.948
		SU4	37.92	31.308	.782	.944

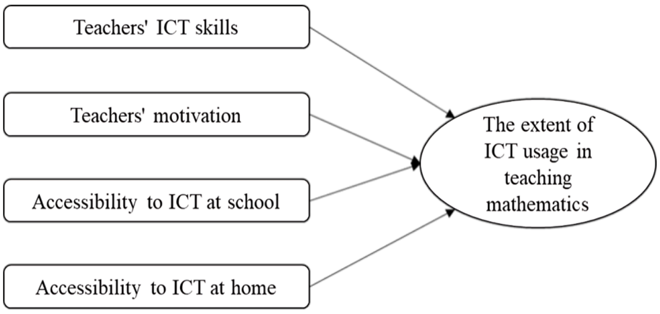

Figure 2. Adjusted model (Source: Authors' own elaboration, 2025)

Based on the EFA results, the authors adjust the research model as shown in **Figure 2**.

Hypotheses to be tested:

H1a: Teachers' ICT skills positively impact the extent of ICT usage in mathematics teaching.

H2a: Teachers' motivation positively impacts the extent of ICT usage in mathematics teaching.

H3a: Accessibility to ICT at school positively impacts the extent of ICT usage in mathematics teaching.

H4a: Accessibility to ICT at home positively impacts the extent of ICT usage in mathematics teaching.

Linear Regression Analysis

Linear regression analysis was conducted to determine the linear regression coefficients of the four variables (skill, motivation, accessibility to ICT at school (AccessS), accessibility to ICT at home (AccessH)) with the extent of ICT usage in mathematics teaching (US) (**Table 8**). The general form of the regression model is

$$US = f(Skill, Motivation, AccessS, AccessH).$$

The regression equation predicting the extent of ICT usage in mathematics teaching is as follows:

$$US = \beta_0 + \beta_1.Skill + \beta_2.Motivation + \beta_3.AccessS + \beta_4.AccessH + \varepsilon.$$

The results of the linear regression model analysis have an F-statistic value of 42.876 and a sig. value of 0.000, indicating that the multiple linear regression model is suitable and usable. The variance inflation factors (VIF) of the variables in the model are all less than 2.0, showing no multicollinearity. The Durbin-Watson value is 2.167, which lies between 1.5 and 2.5, indicating no violation of the first-order autocorrelation assumption, the collected data is good. The adjusted R^2 value of 0.452 indicates that the independent variables included in the regression analysis account for 45.2% of the variability in the dependent variable.

The analysis results show that with a significance level of sig. = 0.05, three out of four independent variables statistically significantly affect the dependent variable. The variable Accessibility to ICT at home (AccessH) does not affect the extent of ICT usage in mathematics teaching (US).

The unstandardized regression equation is:

$$US = -0.190 + 0.588.Skill + 0.173.Motivation + 0.159.AccessS + \varepsilon.$$

The standardized regression equation is

$$US = 0.525.Skill + 0.136.Motivation + 0.164.AccessS + \varepsilon.$$

Thus, the three factors **Skill, Motivation**, and **AccessS** explain 45.2% of the variability in the dependent variable, which is the extent of ICT usage in mathematics teaching (US). Among these, the factor **Skill** has a more significant impact. Therefore, hypotheses **H1a**, **H2a**, and **H3a** are accepted, and hypothesis H4a is rejected.

While the VIF were all well below the threshold of 2.0, indicating that multicollinearity was not a problematic issue for the overall regression model validity, it is important to acknowledge the presence of some correlation among the predictors (skill, motivation, accessS). This means that the interpretation of individual regression coefficients should be made with caution. These coefficients represent the unique contribution of each predictor after accounting for the variance shared with the other predictors in the model. Therefore, while the direction and significance of the effects are robust, the precise magnitude comparison of their unique impacts might be influenced by these intercorrelations.

Difference Testing

The Sig. value of the test of homogeneity of variances (**Table 9**) is greater than 0.05, meaning that with a 95% confidence level, the variances of the observed variables within the same factor are equal. Thus, the results of the one-way ANOVA test can be applied.

The results of the one-way ANOVA test (**Table 10**) show no differences in the extent of ICT usage in mathematics teaching among groups based on education level and work location. However, there are differences among groups based on gender and years of teaching.

Regarding gender differences, male teachers (mean 3.2026) use ICT more than female teachers (mean 2.9436). Regarding differences based on years of teaching, an in-depth ANOVA analysis was conducted to determine specific differences between groups. Using the LSD test (**Table 11**), the analysis results show that there are differences in the

Table 8. Linear regression coefficients

Model		Unstandardized coefficients		Standardized coefficients	t	Significance	VIF
		B	Standard error	Beta			
	(Constant)	–.190	.308		–.617	.538	
	Skill	.588	.069	.525	8.572	.000	1.391
1	Motivation	.173	.083	.136	2.096	.037	1.560
	AccessS	.159	.060	.164	2.649	.009	1.412
	AccessH	–.011	.075	–.010	–.150	.881	1.598

Note. R^2 = 0.463; Adjusted R^2 = 0.452; Durbin-Watson = 2.167

Table 9. Significance results of the test of homogeneity of variances

	Gender	Education background	Years of teaching	School location
Significance	.930	.065	.952	.685

Table 10. One-way ANOVA results

		Sum of squares	df	Mean square	F	Significance
Gender	Between groups	2.969	1	2.969	4.824	.029
	Within groups	124.336	202	.616		
	Total	127.305	203			
Education background	Between groups	1.411	1	1.411	2.265	.134
	Within groups	125.894	202	.623		
	Total	127.305	203			
Years of teaching	Between groups	6.433	4	1.608	2.648	.035
	Within groups	120.872	199	.607		
	Total	127.305	203			
School location	Between groups	.233	2	.116	.184	.832
	Within groups	127.072	201	.632		
	Total	127.305	203			

Table 11. LSD test results

(I) Group	(J) Group	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
					Lower bound	Upper bound
1 (1–5 years)	2	.19242	.24079	.425	–.2824	.6672
	3	.43113*	.20452	.036	.0278	.8344
	4	.57602*	.21257	.007	.1568	.9952
	5	.52598*	.19825	.009	.1350	.9169
2 (5–10 years)	1	–.19242	.24079	.425	–.6672	.2824
	3	.23871	.19766	.229	–.1511	.6285
	4	.38359	.20597	.064	–.0226	.7898
	5	.33356	.19116	.083	–.0434	.7105
3 (11–15 years)	1	–.43113*	.20452	.036	–.8344	–.0278
	2	–.23871	.19766	.229	–.6285	.1511
	4	.14488	.16210	.372	–.1748	.4645
	5	.09485	.14280	.507	–.1868	.3764
4 (16–20 years)	1	–.57602*	.21257	.007	–.9952	–.1568
	2	–.38359	.20597	.064	–.7898	.0226
	3	–.14488	.16210	.372	–.4645	.1748
	5	–.05004	.15410	.746	–.3539	.2538
5 (over 20 years)	1	–.52598*	.19825	.009	–.9169	–.1350
	2	–.33356	.19116	.083	–.7105	.0434
	3	–.09485	.14280	.507	–.3764	.1868
	4	.05004	.15410	.746	–.2538	.3539

extent of ICT use between group 1 (1–5 years of teaching) and group 3 (11–15 years of teaching), 4 (16–20 years of teaching), and 5 (over 20 years of teaching). Accordingly, group 1 has the highest extent of ICT use.

DISCUSSION

The proposed research model identifies four main factors affecting the extent of ICT usage in mathematics teaching at high schools in Vietnam, including teachers' ICT skills, teachers' attitudes, support, and accessibility to ICT tools. The EFA redefined three groups of factors, including ICT skills, motivation, and accessibility to ICT tools at school. Through multivariate linear regression analysis, the 'accessibility at home' factor was excluded due to not being statistically significant at the 5% level.

The study yields several key findings for discussion:

1. The analysis revealed that teachers' ICT skills have the strongest positive association with the extent of ICT usage compared to motivation and access at school. This finding aligns with previous research by Dhol et al. (2023) and Chapai (2023), which emphasizes that technical competence and pedagogical knowledge on how to use ICT are essential prerequisites for teachers to overcome challenges and effectively integrate technology into their teaching processes.
2. Both motivation and accessibility to ICT at school were also significant positive predictors of ICT usage. The positive impact of these factors is consistent with the literature (e.g., Sawyerr & Agyei, 2023; Trujillo-Torres et al., 2020). Similarly, the significance of school-based access highlights the practical importance of readily available and functional ICT infrastructure within the immediate teaching environment.
3. The finding that male teachers tend to use ICT more than female teachers is consistent with several international studies (Gebhardt et al., 2019; Hinojo-Lucena et al., 2019; Ikwuka et al., 2020; Semerci & Aydin, 2018), although it contradicts others like Peng et al. (2023). This difference warrants further investigation in the Vietnamese context. It might reflect disparities in confidence, access to advanced training, perceived societal roles, or time constraints faced by female teachers. Addressing these potential barriers is crucial for ensuring equitable technology integration.

4. The study revealed that teachers with 1 to 5 years of experience exhibited the highest extent of ICT usage, significantly more than those with 11–15 years, 16–20 years, and over 20 years of experience. This finding resonates with studies suggesting newer teachers may be more recently trained in modern pedagogical environments integrating ICT or possess greater dynamism and willingness to experiment (Baroudi & Shaya, 2022; Kalra, 2018; Peng et al., 2023). Conversely, it raises concerns about potential complacency, lack of ongoing training, or resistance to change among more experienced teachers, highlighting a need for targeted professional development strategies.

CONCLUSION AND RECOMMENDATIONS

This study identified three key factors significantly associated with the extent of ICT usage among high school mathematics teachers in Northern Vietnam: ICT skills, motivation, and accessibility to ICT tools at school. ICT skills emerged as the most influential predictor. Furthermore, gender and years of teaching experience were found to be related to variations in ICT usage levels.

Based on these findings, the following recommendations are proposed to enhance the effective integration of ICT in high school mathematics teaching in Vietnam:

1. Prioritize and diversify ICT skills development: To enhance and diversify ICT skills in teaching, it is essential to prioritize their development from pre-service teacher education and sustain continuous professional growth. In teacher preparation programs, practical training in mathematics-specific software such as GeoGebra, Desmos, and statistical packages should be integrated directly into mathematics methods courses. This approach not only familiarizes teachers with essential tools but also emphasizes the creation of practical teaching resources and lesson plans. For in-service teachers, ongoing professional development programs should be regularly conducted and designed with a differentiated approach, focusing on practical application rather than just theoretical knowledge. These programs should cater to various levels, from foundational ICT skills to advanced tool usage such as simulations and modeling, while also fostering the integration of technology to promote higher-order thinking among students. More importantly, professional development should provide hands-on practice and peer collaboration opportunities to build teachers' confidence in utilizing ICT effectively in their teaching. Additionally, these programs must ensure a balanced focus on both technical skills and pedagogical content knowledge (TPACK) relevant to the integration of ICT in mathematics instruction.
2. Foster teacher motivation (attitudes and support): To foster teacher motivation in integrating ICT into mathematics instruction, it is crucial to emphasize its benefits and provide strong institutional support. Professional development programs and school activities should highlight concrete examples of how technology enhances teaching and learning, helping to address any skepticism and build confidence among educators. Encouraging peer-sharing of successful practices further reinforces the practical advantages of ICT in the classroom. At the institutional level, school leaders play a key role in promoting a clear vision for ICT integration by allocating dedicated time for teachers to explore and prepare lessons, establishing policies that recognize and encourage ICT use, and ensuring the availability of technical support. Additionally, fostering a collaborative school culture where teachers actively support one another, such as through lesson study focused on ICT, creates an environment conducive to continuous professional growth and innovation in teaching practices.
3. Enhance school-based ICT accessibility: Enhancing school-based ICT accessibility requires both strategic investment and effective resource optimization. Schools should prioritize sustained investment in reliable and up-to-date ICT infrastructure, including computers, projectors, stable internet connectivity, and necessary software licenses, ensuring that these resources are readily available in classrooms or dedicated labs. At the same time, it is essential to equip teachers with the skills to maximize the use of existing ICT resources in their schools. Providing targeted training on effective technology integration enables educators to make the most of available tools in their teaching. Additionally, developing repositories of high-quality digital learning materials, such as lesson plans, interactive activities, and assessments, aligned with the Vietnamese curriculum will further support teachers in delivering engaging and technology-enhanced mathematics instruction.
4. Address demographic disparities: Addressing demographic disparities in ICT integration requires a targeted approach that ensures equitable access to training and support for all teachers. Promoting gender equity involves identifying potential barriers that female teachers may face, such as time constraints, confidence levels, or limited access to specialized training, and implementing tailored support mechanisms, including flexible professional development opportunities. Encouraging female educators to take on leadership roles as ICT champions can further inspire broader participation. Additionally, recognizing differences in experience levels is essential for designing effective training programs. Early-career teachers, often more enthusiastic about technology, can be engaged in mentoring roles to support their peers, while experienced teachers may benefit from professional development focused on pedagogical innovation with ICT. Addressing potential resistance to change and offering advanced skill development aligned with their expertise will help ensure that all educators, regardless of background, can effectively integrate technology into their teaching practices.

Limitations and Future Research

This study has several limitations. Firstly, the cross-sectional design identifies significant associations but precludes definitive causal conclusions. Secondly, the focus on Northern Vietnam may limit the generalizability of findings. Thirdly, reliance on self-reported data introduces potential response bias. Finally, while regression analysis identified key predictors, employing Structural Equation Modeling (SEM) could provide a more nuanced understanding of the interrelationships among the latent constructs examined.

Future research could address these limitations by using longitudinal or mixed-method designs for deeper insights and causal exploration. Expanding the geographic and demographic scope within Vietnam is also recommended. Investigating the effectiveness of specific ICT tools, including emerging AI applications in mathematics education, presents another valuable direction. Applying SEM is particularly encouraged in future quantitative studies to model the complex interplay between teacher skills, motivation, access, and ICT integration more comprehensively. Despite its limitations, this study provides a useful foundation for developing targeted interventions to enhance ICT use in Vietnamese mathematics education.

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Data availability: Data generated or analyzed during this study are available from the authors on request.

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