


Determinants of high school STEM teachers' attitudes toward online education

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ABSTRACT

In the era of the Fourth Industrial Revolution, information technology has catalyzed a transformative shift in education. In particular, the shift to online learning during the COVID-19 pandemic has profoundly altered the learning and teaching methods within the global education system. To achieve optimal performance in the realm of online education, this paper seeks to explore the factors affecting the attitudes of science, technology, engineering, and mathematics (STEM) high school teachers toward online teaching in Vietnam, using the technology acceptance model as a framework. Utilizing an online survey, a dataset gathered from 101 teachers with experience in online teaching was assessed using the structural equation modelling method. The outcomes reveal that both perceived ease of use (PEU) and perceived usefulness (PU) exhibit statistically significant direct positive effects on teachers' attitudes toward online education. In addition, the PU of online teaching emerged as a mediator in the link between PEU and teachers' attitudes. The results of this investigation offer valuable insights for instructors and administrators to enhance the quality of high school teacher training, ultimately leading to greater efficiency in online teaching in Vietnam and beyond.

Keywords: online education, technology acceptance model, teachers' attitude, STEM, high school

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INTRODUCTION

With the progression of the industrial revolution and the pervasive influence of information technology across various facets of social life, online learning is emerging as an inevitable trend in the era of Education 4.0 (Almahasees et al., 2021; Baber, 2021; Nair & Das, 2012). Thanks to its effectiveness and convenience, online teaching extends beyond the university level and has expanded to lower levels of education, including K-12; thereby creating new opportunities for educational institutions at the high school level (Huang, 2020; Masry-Herzallah & Stavitsky, 2021). In particular, with the rise of the COVID-19 pandemic, the adoption of online learning has accelerated unexpectedly and robustly. It is considered an optimal solution to address immediate requirements in learning and teaching, proving convenient for training at various levels (Hermanto, 2020; Masry-Herzallah & Stavitsky, 2021). Similarly, in Vietnam, the country is currently in the midst of a comprehensive digital transformation within its education sector, aiming primarily to improve the integration of technology and communication capabilities in teaching and learning. With the strong determination to bridge the gap with more developed countries, online teaching and learning have become focal points of Vietnam's educational strategy, as highlighted in Official Document No. 09/2021/TT-BGDĐT (Ministry of Education and Training [MOET], 2021).

However, achieving smart classrooms and smart schools necessitates more than just the backing of an information technology platform; it also demands a substantial investment in high-quality human resources. In other words, the challenge lies in not only implementing online teaching but also considering teachers' attitudes towards this approach to enhance the overall quality of instruction. The introduction of online teaching has generated considerable confusion among the teaching staff during the initial stages of familiarization and adaptation to this new instructional method. In particular, when applied in teaching science, technology, engineering, and mathematics (STEM) subjects, educators encounter numerous challenges in the online teaching environment. There is apprehension that educators may hesitate to adopt this novel approach to online teaching, influenced by factors like aversion to innovation, self-confidence issues, workload concerns, and other influencing factors (Wingo et al., 2017). Therefore, it is essential to investigate the factors that may influence teachers' attitudes toward online teaching since instructors are pivotal to achieving significant success in the education system (Almahasees et al., 2021; Chandwani et al., 2021; Drueke et al., 2021; Hermanto, 2020).

For this reason, studies exploring educators' perspectives on online teaching has been conducted in different countries, for example China (Wang et al., 2020, 2021), Korea (Baber, 2021), India (Chandwani et al., 2021; Nair & Das, 2012), Indonesia (Hermanto, 2020; Mailizar et al., 2021). Various theories, such as self-determination theory and the

technology acceptance model (TAM), have been employed in these studies with the purpose of exploring teachers' attitudes toward the Internet-based teaching delivery (Drueke et al., 2021; Wingo et al., 2017). According to the literature, the TAM has attracted significant attention in e-learning studies and is considered a robust framework for understanding the factors that shape faculty members' attitudes toward virtual teaching methods (Luik & Taimalu, 2021; Mailizar et al., 2021; Teo et al., 2008; Wingo et al., 2017; Yuen & Ma, 2008). Examples from those studies indicated that perceived usefulness (PU) and perceived ease of use (PEU) are the two main predictors of teachers' attitudes towards technology use (Teo et al., 2008) while others argued that one of them was not a significantly influential factor (Luik & Taimalu, 2021). Nevertheless, although the TAM has been extensively used in research concerning technology users' intentions, its application in studying users' attitudes, specifically in the context of online teaching in the field of education, remains limited. In addition, most of these studies have focused on university faculty with limited investigation into the perspectives of high school teachers regarding web-mediated course delivery. For instance, while the attitude toward online learning platforms among university lecturers was examined in studies by Almahasees et al. (2021) and Drueke et al. (2021), research focusing on K-12 teachers' attitudes toward online learning is limited to a few studies, such as those by Wang et al. (2020, 2021). Specifically, within the Vietnamese context, there is a scarcity of studies focusing on the application of the TAM to assess high school teachers' experiences and attitudes toward online teaching.

For this reason, this study was performed to clarify the factors influencing teachers' attitudes toward online STEM teaching in Vietnamese high schools, utilizing the TAM model as a theoretical foundation. The research adopts structural equation modeling (SEM) to detect the relationships among three variables in a TAM, namely PU, PEU, and attitudes towards online teaching. By comprehending the relationships among these variables influencing teachers' attitudes, this study is expected to serve as a guide for formulating suitable policies that promote conducive environments for online teaching in educational institutions at the general level in the future. This, in turn, contributes to improving the quality of high school teacher training, aligning with the trends of the 4.0 revolution in education and training in Vietnam and other countries as well.

METHODOLOGY

Research Model and Hypotheses

The TAM, formulated by Davis (1989), being one of the most effective models for exploring the individuals' intention to adopt advanced technology. The original TAM model contains the following primary pillars, PEU and PU, deemed as crucial indicators reflecting users' attitudes and intentions towards the adoption of technology. In addition, the TAM also states that PEU directly correlates with PU, confirming that the PU of technology is a main determinant of users' attitudes, mediating the relationship between PEU and attitude (Davis, 1989; Davis et al., 1989). It has been widely utilized in academic literature, particularly in the context of studying teachers' attitudes toward online teaching (Baber, 2021; Fathema et al., 2015; Keong et al., 2014; Mailizar et al., 2021; Teo, 2019; Yuen & Ma, 2008). Building upon findings from the aforementioned studies, within the context of implementing online learning in Vietnam, this study adopts the TAM

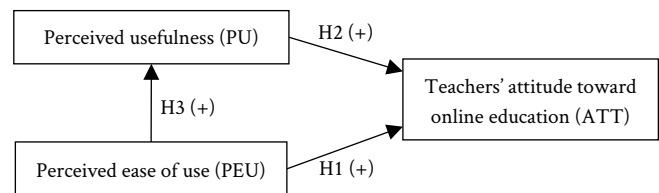


Figure 1. Proposed research model (Source: Author)

model, as shown in **Figure 1**. In this model, teachers' attitudes toward online education are evaluated based on two major factors: perceived usefulness and perceived ease of use.

As proposed in framework, teachers' attitude towards online education pertains to the extent of a teacher's favorable or unfavorable sentiments regarding online teaching, which can profoundly influence the achievement in virtual education (Baber, 2021; Teo, 2019). An instructor exhibiting a positive outlook on digital teaching not only contributes to the improvement of education quality but also demonstrates the motivation to surmount challenges associated with the advanced teaching experience (Taylor & Watson, 2003). Based on the TAM, this attitude is affected by two variables, PEU and PU. PEU refers to "the degree to which an individual believes that using a particular technology would be free of effort" (Davis, 1989; Davis et al., 1989). A recent study conducted by Nguyen (2023) found that PEU did not significantly predict teachers' attitudes toward using online teaching. However, most of investigations have affirmed that the ease of manipulation, utilization, and control of the online teaching system positively influences teachers' attitudes when employing this teaching method (Baber, 2021; Fathema et al., 2015; Wang et al., 2021). Regarding this concept, the below research hypothesis is developed:

Hypothesis 1 (H1): PEU positively influences high school teachers' attitude towards online education.

Besides, PU represents "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989; Davis et al., 1989). PU can be described as the degree to which an individual believes that incorporating virtual teaching would improve their teaching performance. Findings from prior studies reported that a higher PU has a significant positive influence on teachers' attitudes toward online teaching (Baber, 2021; Drueke et al., 2021; Keong et al., 2014; Kisanga, 2016; Luik & Taimalu, 2021; Teo, 2012). For example, PU was reported to be the strongest predictor of attitude toward online teaching activities among high school teachers in Vietnam (Nguyen, 2023). In line with this concept, the following hypothesis is developed:

Hypothesis 2 (H2): PU positively influences high school teachers' attitude towards online education.

Moreover, in the TAM model (Davis, 1989), correlation between PEU and PU is also proposed, which suggests that the higher the PEU, the greater the PU. In other words, PU acts as a mediator in connecting PEU to attitude (Fathema et al., 2015; Teo et al., 2008). Several studies confirmed that the PEU was highly correlated with PU, implying the fact that the PEU had an indirect effect on attitude toward using technology through the mediator variable of PU for teachers (Luik & Taimalu, 2021; Nguyen, 2023). Based on this relationship, the following hypothesis is developed:

Hypothesis 3 (H3): High school teachers' PEU positively influences their PU of online education.

Table 1. Questionnaire items

Questionnaire items	References
Perceived ease of use (PEU)	
PEU1. It is easy for me to perform online teaching	Baber (2021), Fathema et al. (2015), Keong et al. (2014), Kisanga (2016), Teo (2012), Wang et al. (2021), and Yuen and Ma (2008)
PEU2. It is convenient to utilize online platforms (Zoom, MS Teams, Google Meet, etc.) for delivering lectures	
PEU3. It is not complicated to execute online teaching and deliver lessons that are fully aligned with my design	
Perceived usefulness (PU)	
PU1. Engaging in online education proves beneficial for my teaching tasks	Baber (2021), Fathema et al. (2015), Keong et al. (2014), Kisanga (2016), and Teo (2012)
PU2. Engaging in online education facilitates my teaching tasks	
PU3. Engaging in online teaching enables me to teach more effectively	
PU4. Engaging in online teaching enables me to enhance my knowledge and acquire new skills	
Teachers' attitude toward online education (ATT)	
AT1. Teaching online is an interesting experience	Fathema et al. (2015), Jogezei et al. (2021), and Teo (2012, 2019)
AT2. Online teaching is an essential method in contemporary education	
AT3. I enjoy online teaching	

Questionnaire Development

There are two sections in the questionnaire. The first section is about a set of questions rated on a 5-level Likert scale (ranging from 1 point for a strongly disagree response to 5 points for a strongly agree response) to assess the three latent variables outlined in the conceptual model (PEU, PU, and teachers' attitudes toward online education). The details of these questions are presented in **Table 1**. Next section includes inquiries concerning the interviewee's information.

Data Sampling and Collection

The survey focused on a cohort of high school teachers who work full-time and have experience in teaching online. The participants in this survey are STEM teachers from various high schools in Da Nang City, located in the Midlands of Vietnam, equidistant from the northern capital of Hanoi and the southern city of Ho Chi Minh. Serving as the prominent education and training hub in the central region and highlands of Vietnam, Da Nang is the third-largest in the country, following Hanoi and Ho Chi Minh City. The city hosts 24 universities and colleges, 19 professional high schools, 59 vocational training centers, and over 200 schools spanning from primary to senior high school levels. Following the approval of school principals in 12 high schools in Danang, a snowball sampling method was employed to gather primary data through an online survey using Google Forms from August to September 2022. A total of 125 teachers were sent the interview link, and subsequently, the survey received 125 responses, achieving a response rate of 100%. Among these, 24 responses were eliminated because of incomplete data. Consequently, 101 responses were verified as valid and included in the further analysis. This sample size is satisfactory and aligns with the recommended range of 100 to 150 cases for SEM analysis (Kline, 2015).

Data Analysis

The data analysis techniques adopted in this study encompass:

- (1) descriptive statistics,
- (2) exploratory factor analysis (EFA),
- (3) the test of internal consistency reliability (Cronbach's alpha measure), and
- (4) SEM that includes measurement model (confirmatory factor analysis [CFA]) and structural model (path analysis).

The collected data were processed and analyzed utilizing statistical packages for social sciences (SPSS, version 22, IBM Corp., Armonk, NY), and analysis of moment structures (AMOS, version 22, IBM Corp., Armonk, NY) softwares.

Table 2. Teachers' profiles

Participants' attributes	Quantity	Proportion (%)
Gender		
Female	83	82.2
Male	18	17.8
Age (years old)		
22-29	11	10.9
30-39	48	47.5
40-49	33	32.7
50-59	9	8.9
Training level		
Bachelor	53	52.5
Master	48	47.5
Teaching subjects		
Sciences		
Physics	21	20.8
Chemistry	26	25.8
Biology	16	15.8
Technology	10	9.9
Engineering	9	8.9
Mathematics	19	18.8
Teaching experience		
1-5 years	13	12.9
6-10 years	9	8.9
11-15 years	33	32.7
16-20 years	28	27.7
Higher than 20 years	18	17.8
Total	101	100

NY), and analysis of moment structures (AMOS, version 22, IBM Corp., Armonk, NY) softwares.

RESULTS AND DISCUSSION

Respondents' Profiles

Descriptive statistics were employed to examine the demographic information of teachers who participated in the research survey. The details, including gender, age, training level, teaching subjects, and teaching experience, are presented in **Table 2**. The majority of the interviewed teachers were female, constituting 82.2%, with only 17.8% being male teachers. This aligns with the overarching trend of the teaching profession being predominantly female in the general education system. The age distribution of survey participants was primarily between 30 and 39 years old, representing nearly half of the

Table 3. Measurement model's validity

Factors	Observed variables	Factor loadings	CR	AVE	HTMT ratio		
					PU	PEU	ATT
Perceived usefulness (PU)	PU1	0.859	0.870	0.632			
	PU2	0.781					
	PU3	0.914					
	PU4	0.588					
Perceived ease of use (PEU)	PEU1	0.810	0.848	0.650	0.763		
	PEU2	0.745					
	PEU3	0.860					
Teachers' attitude toward online education (ATT)	ATT1	0.886	0.864	0.682	0.878	0.831	
	ATT2	0.716					
	ATT3	0.865					

respondents (47.5%), followed by teachers aged 40 to 49 years old (32.7%). The distribution of teachers among the junior and senior categories was relatively balanced, with 10.9% and 8.9%, respectively. The trend in the number of years of teaching experience mirrors that of age, with the majority of teachers having 11-15 years of teaching experience, accounting for 32.7%. In terms of training level, an almost equal number of teachers possessed bachelor's and master's degrees (52.5% and 47.5%, respectively). Regarding teaching subjects, the majority of teachers were responsible for teaching sciences, including physics (20.8%), chemistry (25.8%), and biology (15.8%). This is followed by those in charge of teaching mathematics (18.8%), while teachers specializing in technology and engineering were nearly evenly distributed (9.9% and 8.9%, respectively).

Exploratory Factor Analysis and Cronbach's Alpha Measures

EFA is a commonly used measurement model employed when it is presumed that both observed and latent variables are measured at the interval level. In this study, the performance of principal component analysis with varimax rotation was done to clarify the relationships within the observed items. The results of the EFA reveal a Kaiser-Meyer-Olkin coefficient of 0.869, which is greater than 0.7, affirming the appropriateness and statistical significance of the analysis. The Bartlett's test of sphericity, with a Chi-square value of 400.303 and significance of 0.000 (less than 0.05), indicates that the question items are correlated with each other (Hair et al., 2019). After the extraction process, two primary factors were identified, representing a total variance extracted of 74.45%, with an Eigenvalue of 1. All original observed items remained as their factor loadings surpassed the suggested threshold of 0.5, which affirms the suitability of the included data in the analysis (Hair et al., 2019). The two newly formed factors are named as "PU" (including four coded items: PU1, PU2, PU3, and PU4) and "PEU" (including 3 coded items: PEU1, PEU2, and PEU3).

To assess the internal reliability of the observed items, this study employed Cronbach's alpha measure. The results indicate that the Cronbach's alpha values for the two independent factors namely 'PU' and 'PEU,' are 0.869 and 0.846, respectively while that for the dependent factor "teachers' attitudes toward online education" is 0.855. It can be seen that all these values exceed the recommended value of 0.7, affirming the appropriateness and reliability of both the independent and dependent scales used in the study (Hair et al., 2019).

Structural Equation Modelling

The SEM, which includes two analytical stages, was utilized to explore path correlations among and within factors in this research's model. The initial stage, referred to as the measurement model, applies

CFA on measuring reliability, convergent validity, and divergent validity. This step assesses the strength of the correlation between the measured items and the latent factor. The latter stage, known as the structural model, involves estimating the proposed relationships among the factors.

Measurement model

This research applies the composite reliability (CR) coefficient, the average variance extracted (AVE), and the single-factor loading coefficient to evaluate the reliability and convergence of the research model. As summarized in **Table 3**, CR and AVE values of three factors are higher than the threshold 0.7 and 0.5, respectively (Fornell & Larcker, 1981; Hair, 2010), implying that the model is reliable and convergent. In addition, to assess the discriminant validity of the model, the heterotrait-monotrait ratio was employed, with a recommended evaluation threshold of less than 0.9 (Henseler et al., 2015). **Table 3** demonstrates that the discriminant validity of the model is satisfied. Overall, the results from the measurement model indicate that the criteria for reliability, convergence and discrimination are verified, making it suitable for predicting the structural model and testing related hypotheses.

To evaluate the fit of the measurement model, the model fit indices are scrutinized in CFA, consisting of relative Chi-square (CMIN/df), the root mean square residual (RMR), the goodness of fit index (GFI), the parsimonious goodness-of-fit index (PGFI), the normed fit index (NFI), the Tucker-Lewis index (TLI), the comparative fit index (CFI), the parsimonious normed fit index (PNFI), and the parsimony comparative fit index (PCFI), the standardized root mean square residual (SRMR).

As can be seen in **Table 4**, all these indices meet the standard threshold, indicating that the measurement model is compatible with the collected dataset.

Structural model

The connections among factors outlined in the research model were assessed through the path coefficients.

As shown in **Figure 2**, the overall R^2 of the model is 0.830, indicating that 83.0% of the variance in attitude was accounted for by its influencing factors, specifically PU and PEU. Since R^2 ranges from 0 to 1, in which a higher value signifies an enhanced predictive capability of the model, the result of 0.830 suggests notably high acceptability in studies associated with technology acceptance (Teo, 2019). Additionally, serving as a mediator, changes in PU were explained by PEU to the extent of 54.9% ($R^2 = 0.549$).

Table 4. Goodness-of-fit

Model fit index	Value	Standard (Hair et al., 2019; Kline, 2015)	Conclusion
CMIN			
CMIN/df	1.711	≤ 2	Appropriate
RMR & GFI			
RMR	0.040	≤ 0.080	Appropriate
GFI	0.896	≥ 0.850	
PGFI	0.521	≥ 0.500	
Baseline comparisons			
NFI	0.923	≥ 0.900	Appropriate
TLI	0.952	≥ 0.900	
CFI	0.966	≥ 0.900	
Parsimony-adjusted measures			
PNFI	0.656	≥ 0.500	Appropriate
PCFI	0.687	≥ 0.500	
RMSEA			
RMSEA	0.080	≤ 0.080	Appropriate

Table 5. Results from hypothesis testing

Hypothesis testing	Coefficient	p-value	Standard error	Conclusion
H1: PEU → ATT	0.403	< 0.001	0.134	Accepted
H2: PU → ATT	0.571	< 0.001	0.104	
H3: PEU → PU	0.741	< 0.001	0.136	

logical because the PU in this concept is associated with the practical advantages of adopting online teaching, which is particularly reasonable in this study involving STEM teachers in high schools. Consequently, an improvement in its effectiveness is likely to foster a greater readiness among teachers to participate in online teaching activities. Therefore, the emphasis should be placed on the effectiveness of virtual education, with a focus on enhancing the favorable attitude of teachers towards a teaching method with advanced technology.

Beside PU, the PEU is also an important influential driver of teachers' attitude towards online teaching, which aligns with previous studies by Mailizar et al. (2021) and Nair and Das (2012). Given that STEM includes many practical and experimental subjects, thereby, the ease of applying online teaching may be a strong catalyst that motives teachers to involve in this method of education. Additionally, a study in India revealed that only PEU influenced attitudes of mathematics teachers' in online teaching (Nair & Das, 2012). This can be attributed to the notion that the ease with which teachers can access, manipulate, and use the system stimulates and creates conditions that encourage enthusiastic participation in online teaching.

Furthermore, the results from this study indicate that PEU also positively affects the PU of using online formats in teaching, having a coefficient of 0.741 (p-value < 0.001). This high correlation is consistent with prior research findings (Mailizar et al., 2021; Nair & Das, 2012) that suggests that ease of use enhances teachers' focus on information, thereby promoting high efficiency. This significant relationship also indicates that PEU indirectly influences the attitude of teachers in using technology mediated by the PU. Luik and Taimalu (2021) also affirmed comparable results, highlighting that a perception of ease in applying technology for teaching leads to a heightened positive belief among teachers regarding the effectiveness of online teaching.

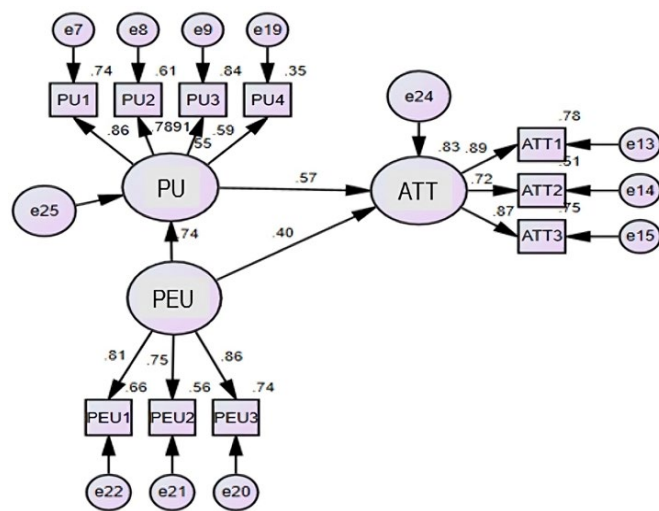


Figure 2. The structural model (Source: Extracted from AMOS using data input from the current research)

The results from testing the structural model indicate that all three hypotheses (H1, H2, and H3) are accepted with a confidence level of 99% (Table 5). The structural model estimation results reveal positive regression weights for the relationships specified in hypotheses H1, H2, and H3, concluding that all independent factors positively affect the dependent variable. Specifically, PEU and PU both exert a positive influence on attitudes of teachers in teaching online, in which PU performs a stronger impact, as evidenced by the larger beta coefficient value of 0.571 (PU → ATT) compared to 0.403 (PEU → ATT). This finding aligns with previous studies by Yuen and Ma (2008) and Fathema et al. (2015), suggesting that PEU and PU perform an important role in predicting teachers' attitude in the case of online teaching.

The PU of advanced teaching methods is assumed to be highly significant impact on STEM high school teachers in this study. In simpler terms, when teachers perceive online-based teaching methods as beneficial for enhancing their performance, they are inclined to cultivate a robust positive perspective toward adopting online teaching. This finding is consistent with existing studies that have illustrated how every unit increase in PU contributes to an enhanced favorable attitude among instructors (Luik & Taimalu, 2021; Protas et al., 2016). This is

CONCLUSIONS AND SUGGESTIONS

Utilizing the TAM, this investigation examined the factors influencing the attitude of STEM high school teachers towards online education. The research findings have revealed a positive relationship between PU and PEU with the attitudes of teachers in high schools. Additionally, the PEU indirectly influences the attitude of teachers in using technology mediated by the PU. Hence, to leverage the favorable impact of attitude on online education, cultivating a positive standpoint of the effectiveness of virtual teaching should be a key emphasis. When teachers recognize online teaching as a valuable approach, they are more likely to adopt it. Building upon these results, the following recommendations are suggested to enhance the quality of the online teaching process, aligning with the inevitable trend of the 4.0 revolution in education and training. Specifically:

- (1) **For educational management:** Enhance the training of teachers with knowledge and skills to meet the requirements of digital transformation, encompassing fundamental skills such as information technology application, proficiency in software usage, and competence in online teaching systems.

(2) **For high school teacher training:** In addition to imparting specialized knowledge, prospective teachers should simultaneously undergo training in soft skills and proficiency in coordinating the use of technology. This preparation is crucial for swiftly meeting the urgent requirements of professional practice in the 4.0 Education era. Teacher training institutions should contemplate the development of practice and pedagogical practice modules that integrate online teaching models. The objective is to comprehensively equip future teachers with the necessary knowledge, skills, and attitudes, enabling them to adapt to the evolving landscape of modern teaching methods during the digital development era.

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Declaration of interest: The author declares no competing interest.

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

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