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INFLUENCES ON PRESCHOOL TEACHERS' WILLINGNESS TO PERSIST IN IMPLEMENTING STEM/STEAM ACTIVITIES: AN INVESTIGATION IN VIETNAM

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Abstract

Pre-school years are considered a natural starting point for STEM/STEAM education. Along with state policies, school support, and other resources, teachers play a crucial role in a successful implementation of STEM/STEAM education at kindergartens. The issue of preschool teacher training and support to develop STEM/STEAM teaching competency has been discussed in some research. However, it is claimed that after attending STEM/STEAM education training and support programmes to enhance teachers' STEM/STEAM knowledge, some teachers do not have the intention of maintaining the implementation of STEM/STEAM education. With the aim of identifying the factors affecting the intention of preschool teachers to maintain the practice of STEM / STEAM education, the study uses individual behaviour prediction models based on the factors with potential influence on teachers' decisions. A qualitative study was conducted with the sample of 1278 in-service preschool teachers in Vietnam. The preliminary results of the research show that the most influential factors that affect the intention of Vietnamese preschool teachers to maintain STEM/STEAM education activities are the perceived behavioural control of teachers with STEM/STEAM education, including teacher self-efficacy in STEM/STEAM education, and facilitating conditions for STEM/STEAM education. Other factors such as teacher attitude / emotional readiness for STEM/STEAM education; perceived usefulness, subjective norms; and perceived behavioural control of STEM/STEAM education.

Keywords – Factors affecting, Intention of maintaining, STEM/STEAM education, Preschool education, Vietnam.

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1. Introduction

STEM (Science, Technology, Engineering, and Mathematics) is an interdisciplinary approach that integrates these four disciplines to foster critical thinking, problem-solving, and innovation. In contrast, STEAM (Science, Technology, Engineering, Arts, and Mathematics) expands this framework by incorporating Arts, emphasizing creativity and design as essential components of holistic learning (DeJarnette, 2018). While STEM focuses on technical and analytical skills, STEAM bridges the gap between scientific rigor and artistic expression, aligning with young children's natural curiosity and imaginative tendencies (Spyropoulou, Wallace, Vassilakis & Poulopoulos, 2020).

Since its formal promotion in the United States in 2009, STEM education has received growing global attention as a key driver of 21st-century skills development across all levels of education —from preschool to higher education (Morgan, Smaldone, Selin, Deng & Holmes, 2022). The preschool years are widely considered a critical starting point for STEM learning (Katz, 2010), as young children begin forming foundational understandings of the world through exploration. Integrating science with mathematics, engineering, and technology in early childhood settings enhances children's awareness of scientific phenomena and nurtures their interest in inquiry-based learning (Rasyid, Sugandi, Gaffar, Jatisunda, Santoso & Nahdi, 2021). Such early experiences not only build a strong base of cognitive skills but also contribute to children's long-term academic trajectories (Yelland, 2021; Hapgood, Czerniak, Brenneman, Clements, Duschl, Fleer et al., 2020). However, young learners require considerable support in navigating these learning experiences, thus highlighting the essential role of preschool teachers in delivering STEM/STEAM education effectively (Simoncini & Lasen, 2018).

The implementation of STEM/STEAM education in early childhood varies significantly across countries. In developed contexts such as the United States and members of the European Union, this approach is supported by robust infrastructure, standardized curricula, and comprehensive teacher training programs. For example, Papadakis and Kalogiannakis (2020) noted that preschool teachers in Greece and Finland are encouraged to use educational robotics and digital tools to introduce computational thinking from an early age. A systematic review by Larkin and Lowrie (2023) further revealed that of 61 empirical studies on STEM integration in preschool and primary education, 19 were conducted in the United States, reflecting a strong interest in the field. Nevertheless, only around 8% of these studies demonstrated fully integrated STEM curricula, indicating that even in high-resource settings, challenges to implementation remain.

In comparison, the emerging economies of Vietnam present a vastly different scenario. Significant concerns are limited instructional resources, unevenly qualified teachers, and a high dependence on traditional instructional practices (Dinh, 2021). Whereas China and Thailand incorporated STEM/STEAM education in their national education policies in the mid-2010s (Cheng, Buntting & Jones, 2022; Promkatkeaw, Seetee & Dahsah, 2022), the uptake has been sluggish in Vietnam. For example, Bui, Tran, Nguyen, Nguyen-Thi, Tran, Dang et al. (2023) discovered that only 8% of preschool teachers in rural areas had heard of STEM concepts. These results highlight the need for context-based measures addressing Vietnam's peculiar educational and cultural circumstances.

With teacher competency playing a crucial role in effective STEM/STEAM implementation, numerous studies have investigated the use of professional development programs in the case of early childhood teachers. Mesutoglu and Corlu (2023) proposed the "EarlySTEM" program of instructional support and material provision during the school year. Their research improved teacher knowledge, teaching practices, and student participation considerably. Likewise, Rogers, Winship and Sun (2015) promoted using interactive and social constructivist models in teacher training to facilitate more significant STEAM experiences in young students.

Despite the positive outcomes of such programs, recent research also highlights a concerning gap between competence and intention. Studies by Demircan (2022) and Evagorou (2024) show that even after receiving STEM-focused training, some teachers remain hesitant to continue implementing these practices. This raises important questions about underlying motivational and contextual factors that influence long-term adoption, especially in settings like Vietnam, where systemic barriers persist. Notably, there is still a lack of empirical research focusing on the sustained intention of preschool teachers to implement STEM/STEAM education —particularly in countries with socio-economic and cultural contexts similar to Vietnam.

STEM/STEAM education has garnered increasing attention in Vietnam over the past decade. However, pedagogical research in this area remains limited, especially at the preschool level (Bui et al., 2023). Most preschool teachers still rely on conventional, teacher-centered methods, and only a tiny proportion have the knowledge and confidence to organize STEAM activities, particularly in disadvantaged regions (Dinh, 2021). Although various government and institutional training initiatives have been launched to improve teacher capacity, the actual application of STEM/STEAM in preschool classrooms remains inconsistent. Furthermore, there is growing concern about the sustainability of such efforts, as many teachers do not maintain these practices after training.

Given these challenges, it is essential to understand better the factors influencing teachers' willingness to persist in implementing STEM/STEAM education. These insights are crucial for informing the design of more effective training programs, professional support systems, and policy frameworks. This study, therefore, aims to investigate the key determinants of Vietnamese preschool teachers' intention to maintain STEM/STEAM activities in their classrooms. It contributes to both the local educational discourse and the broader international literature on early childhood STEM/STEAM education.

In this study, the authors used the qualitative research method to determine the degree of influence of factors on the intention of Vietnamese preschool teachers to continue organizing STEM/STEAM education activities. Based on the survey responses of 1278 preschool teachers in Vietnam, the study seeks to answer the following research questions. RQ1: What are the factors that affect the intention of Vietnamese preschool teachers to maintain STEM/STEAM education activities? RQ2: To what extent do these factors affect the intention of Vietnamese preschool teachers to maintain STEM/STEAM education activities? The research findings can help propose appropriate solutions and policies to promote the implementation of STEM / STEAM education in kindergartens in Vietnam in particular and countries with similar conditions in general.

2. Literature Review

2.1. STEM/STEAM Education in Preschool

STEM/STEAM in preschool improves children's knowledge of scientific concepts and interests and the development of problem-solving, creativity, and 21st-century skills (Aldemir & Kermani, 2017; Nikolopoulou, 2023). Incorporating art in STEM also nurtures creativity and comprehensive development (DeJarnette, 2018). Implementation of the models, however, relies heavily on preschool teachers' desire and capacity to continue such activities, which is moderated by diverse factors, especially in a context like Vietnam's. Although numerous nations have incorporated STEM/STEAM in preschool curricula with favorable policies and teacher development (Cheng et al., 2022; Promkatkeaw et al., 2022), Vietnam also confronts specific challenges of limited awareness of preschool teachers, poor training, and cultural barriers that might deter preschool teachers' intentions to implement the activities.

Teacher support plays a significant role in the practical realization of STEM/STEAM education, and technology is a primary support source in the fourth industrial revolution. Papadakis, Vaiopoulou, Sifaki, Stamovlasis, Kalogiannakis and Vassilakis (2021) note that preschool teachers' perceptions, attitudes, and digital competence play a role in the decision to use technology in teaching STEM subjects. Technology tools such as educational robots, simulations, models, and computer games facilitate STEM education by building students' programming and mathematics skills. These tools enable children to conduct experiments, develop problem-solving, and acclimate themselves to technology (Nikolopoulou, 2022). STEM/STEAM education also develops children's knowledge through digital learning (Fridberg & Redfors, 2023), and play is necessary for their development (Aranda, Campbell, Ferguson & Speldewinde, 2022). Augmented Reality (AR)-based tools, including the ARISP module, promote children's engagement and comprehension of STEM subjects (Wang, Abdul-Rahman & Nizam-Shaharom, 2024). Integrating technologies such as IoT, 3D printing, and AI benefits teachers and students by improving learning outcomes (García-Sánchez, Candia-García & Vargas-Martínez, 2024). However, challenges persist, such as teachers' resistance to technology use due to concerns over its suitability for young children (Clements & Sarama, 2016) and limitations in resources and training (Papadakis, Gözüm, Kaya, Kalogiannakis & Karaköse, 2024).

In Vietnam, STEM education started to gain interest in the 2010s, and it was then officially included in the curriculum by the Ministry of Education and Training. Although many teacher training programs have been implemented, STEM education at the preschool stage continues to present an implementation problem. Only 8% of preschool teachers in Vietnam were informed of STEM education, according to a study by Dinh (2021). Teachers lack confidence in the use of STEM/STEAM, especially those who have worked for more than 15 years or who are ethnic minority group members. Despite enhanced teacher training, there continues to exist a wide diversity of interpretations of the kind of knowledge and ability of the teachers in using STEM/STEAM education, and many of them use more conventional, teacher-centered practices rather than more interactive practices (Shaw, Traunter, Nguyen, Huong & Thao-Do, 2021). Vietnamese parents discourage "trial and error" practices and use more conventional education (Hien, 2018). Teachers are also faced with other duties, including healthcare and childcare, which complicate the implementation of STEM/STEAM in preschools.

Thus, understanding the contextual differences between global practices and Vietnam's specific challenges is crucial for identifying factors influencing Vietnamese preschool teachers' intention to maintain STEM/STEAM education (RQ1). Moreover, this comparison helps assess how significantly these factors affect their intentions (RQ2).

2.2. Teachers' Roles in STEM/STEAM Education Implementation at Preschool Education Level

Teachers bridge the STEM/STEAM education system and children and play a crucial role in instilling motivation and academic achievement (Falloon, Hatzigianni, Bower, Forbes & Stevenson, 2020). Their interactions, instructional approaches, and support are crucial in developing a positive learning environment in which children achieve STEM knowledge and skills (Chen & Tippett, 2022; Speldewinde & Campbell, 2023). Nevertheless, preschool teachers tend to struggle due to a wide range of training in subjects outside of specialized STEM fields (Ryu, Mentzer & Knobloch, 2019). This provides no specialized training and hence lacks sufficient knowledge and practice, which can result in negative attitudes toward STEAM education and fear of preparing for STEAM activities (DeJarnette, 2018).

Professional development is essential in building teachers' readiness and intent to introduce STEM/STEAM education. Training, including that utilizing robots or simulators, has proven effective in enhancing the STEM knowledge and confidence of the educators (Fridberg, Redfors, Greca & Terceño, 2023; Aranda et al., 2022). Technical support, including networks of STEM support and collaborative projects (improved by, for example, "STEM Bridge"; Yelland & Waghorn, 2023), can also increase the confidence and intent of the teachers to continue STEM/STEAM activities. However, despite having undergone training, some educators can remain lacking in the confidence and support necessary to carry out these activities, including multiple STEM disciplines (DeJarnette, 2018).

The support systems and roles addressed herein are critical drivers and barriers to the teachers' intentions to continue STEM/STEAM actions and directly address RQ1. Additionally, measuring the efficacy of the support systems regarding the change in the teachers' intentions will shed light on RQ2.

2.3. Preschool Teachers' Capacity and Intention to Implement STEM/STEM Education

Teachers' ability and willingness to conduct STEM/STEAM education are also determined by various factors, including self-confidence, knowledge levels, prior experience, and support at the institutional level (Lange, Nayfeld, Mano & Jung, 2022; Chen, Huang & Wu, 2021). Experienced STEM or competency development program participating teachers tend to feel more confident and willing to carry out such activities (Lange et al., 2022). Nevertheless, even following training, a few participating teachers might lack adequate confidence to sustain STEM/STEAM activities in the case of intricate, integrated content (DeJarnette, 2018). Lack of knowledge in IT can also preclude the effective use of technology by the participating teachers in STEM/STEAM education (Evagorou, 2024).

Teachers in preschools in Vietnam have particular challenges that shape their readiness and intention. For instance, it was revealed by Bui et al. (2023) that the perceptions, competency, and readiness of the teachers depend on limited knowledge of STEM, a lack of adequate instruction of instructional methods, and a lack of support from organizations and schools. Cultural and historical traits also come into play, as traditional instructional practices are the preferred choice of many Vietnamese teachers, and the parents do not emphasize experimental instructional practices (Shaw et al., 2021; Hien, 2018). Such factors cumulatively shape the intention of the teachers to sustain STEM/STEAM activities.

This section clarifies a number of the factors —including self-confidence, knowledge, experience, and institutional support— that shape preschool teachers' intention to continue STEM/STEAM activities, which are at the center of RQ1. Further, the exposition of how training courses enhance competence but not always intention points to the intricacies of these factors' effects, directly addressing RQ2.

3. Research Model

To identify factors affecting the intention to maintain STEM/STEAM education activities in class among preschool teachers, the researchers based individual behaviour prediction models on factors with potential influence on their decision. Many models have been developed and expanded to predict individual behavioral intentions, among which the most influential and widely used in research are: the Technology Acceptance Model (TAM) (Davis, 1989), Theory of Planned Behavior (Ajzen, 1991) and Decomposed Theory of Planned Behavior (DTPB) (Taylor & Todd, 1995).

Among the prominent models predicting individual behavioral intention, the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) are widely used in educational research. TAM, developed by Davis (1989), emphasizes perceived usefulness and perceived ease of use as key determinants influencing user attitudes and behavioral intention toward adopting technology. TAM has been applied in STEM education to examine technology-related teaching practices such as mobile learning and artificial intelligence integration (Chibisa & Mutambara, 2022; Sun, Tian, Sun, Fan & Yang, 2024).

TPB, proposed by Ajzen (1991), builds upon the earlier Theory of Reasoned Action by incorporating perceived behavioral control, attitude, and subjective norms to explain intention and behavior better. TPB has been extensively employed to investigate teachers' intentions in adopting innovative educational practices, including STEM teaching, across various levels and contexts (Lin & Williams, 2016; Do, Hoang, Do Trinh, Nguyen, Tran et al., 2021; Wijaya, Jiang, Mailizar & Habibi, 2022). While both models offer valuable insights, their integration or extension —such as in the Decomposed Theory of Planned Behavior (DTPB)— allows for a more detailed analysis of the belief structures underlying behavioral intention, which is central to this study.

3.1. The Decomposed Theory of Planned Behavior (DTPB)

TPPB was introduced by Taylor and Todd after comparing the TAM and TPB. In this new model, the three impact factors of TPB, namely attitude, subjective norms and perceived behavioral control, are broken down into belief structures at lower levels (Taylor & Todd, 1995).

Attitude includes perceived usefulness, ease of use and compatibility. Subjective norm involves peer influence and Superior's influence. Perceived behavioral control includes self-efficacy, resource facilitating condition, and technology facilitating condition. The DTPB model and others have been verified and compared in different domains, confirming the ability of the DTPB model to predict and explain more precisely by adding decomposed variables. This model has been widely used in research on various topics such as the intentions of preservice teachers to apply information technology (Ndlovu, Ramdhany, Spangenberg & Govender, 2020), secondary school teachers to use online learning platforms (Tao, Hsieh, Hsu, Yang & Sia, 2019), factors that affect intentions to implement STEM education of Chinese K12 teachers (Wu, Yang, Hu, Li, Liu, Wang et al., 2022).

In the research, the author adopted the DTPB model as the fundamental theoretical framework to predict and explain comprehensively the factors affecting the intention to continue carrying out STEM education activities among preschool teachers in Vietnam (Figure 1).

The hypothesis framework of this study is presented in the figure below. The dependent variable is preschool teachers' intention to keep organizing STEM education activities. The three factors determining preschool teachers' intention to maintain STEM education activities are Attitude, Subjective norm, and Perceived behavioral control according to the DTPB model (Taylor & Todd, 1995). However, the three factors affecting perceived behavioral control were regrouped into two component factors, namely Self-efficacy and Facilitating conditions, as it is proved in many previous studies that resource facilitating conditions and technology facilitating conditions are favourable conditions to carry out the intended behavior (Teo, 2011; P. Wu et al., 2022). In summary, the variables will include Attitudes include Perceived usefulness, Ease of use, and Compatibility. Subjective norms include Peer influence and Superior influence. Perceived behavioral control includes Self-efficacy and Facilitating conditions.

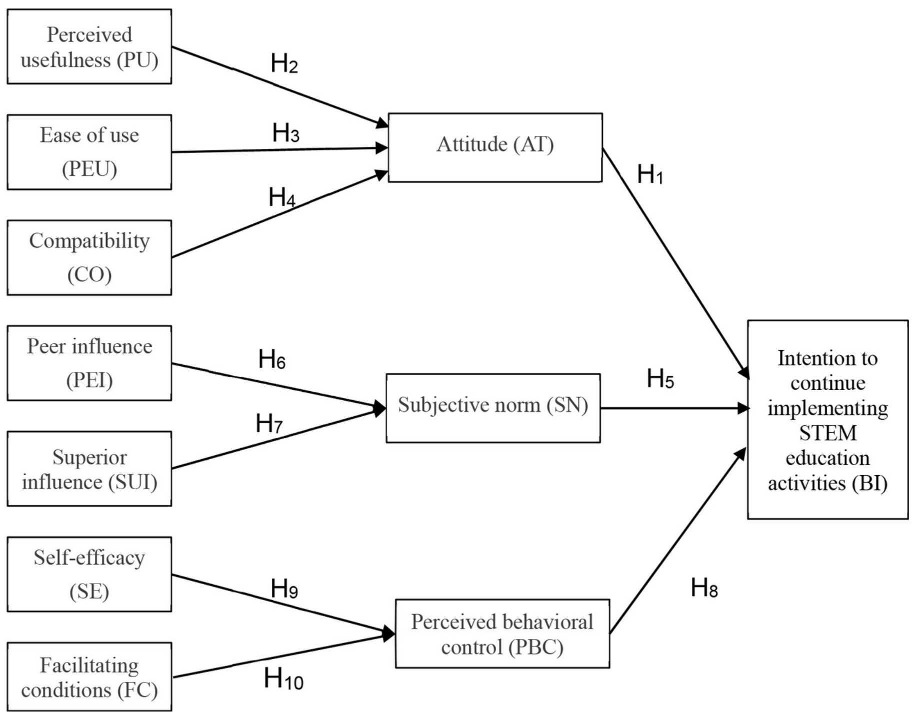


Figure 1. Proposed Framework with Initial Hypotheses

Looking at the hypothesis model, the 10 hypotheses developed to answer the research questions can be elaborated as follows:

3.2. Attitude

Emotional readiness in teaching reflects the impacts of teachers' emotions on their teaching efficacy. In the DTPB model, attitude refers to the extent to which an individual view a specific behavior as positive or negative (Ajzen, 1991) and has corresponding effects on whether or not to carry out the targeted behavior (Ham, Jeger & Frajman-Ivković, 2015), similar to the concept of emotional readiness. As a result, to diminish the conceptual complication of the influential factors and simplify the model, attitude and emotional readiness were examined from the same perspectives. The attitude of teachers is evaluated mainly with respect to their ability to create positive emotions when continuing to implement STEM education activities and achieve good results in this task. The influence of attitude on an individual's BI has been strongly advocated in previous studies, positive attitudes will have a positive and direct impact on behavioral intentions (Sadaf & Gezer, 2020; Teo, 2011). Therefore, the following hypothesis is proposed:

H1: The attitude / emotional readiness of preschool teachers for STEM education has a significant influence on their intention to maintain STEM education activities.

Based on the analysis of the DTPB model, attitude is classified into three sub-aspects: perceived usefulness, perceived ease of use, and compatibility. Perceived Usefulness refers mainly to the perceived benefits of STEM education of each teacher when maintaining these activities. Perceived Ease of Use addresses the degree a teacher feels comfortable when using a specific system, as well as the difficulty level when the teacher keeps organising these STEM education activities. Compatibility refers to the level of appropriateness of an existing technology as well as potential values and experiences. It also involves the compatibility between STEM education and teachers' teaching philosophy, current teaching experience, etc. The following hypotheses are proposed:

H2: Perceived Usefulness has a significant influence on teachers' attitude towards continuing implementing STEM education activities.

H3: The perceived ease of use has a significant influence on the attitude of teachers towards continuing to implement STEM education activities.

H4: Compatibility has a significant influence on the attitude of teachers towards continuing to implement STEM education activities.

3.3. Subjective Norm

Subjective norms refers to social pressures causing individuals to perform specific behaviors, reflecting their perception of important reference principles driving an individual to perform or not to perform certain behaviors (Ham et al., 2015). In this study, subjective norms represent teachers' perceptions of the encouragement and acceptance with the behaviors of relevant stakeholders when maintaining STEM education activities. Behavioral subjective norms are generally claimed to be able to predict BI with high precision (Ajzen, 1991). Thus, the following hypothesis is proposed:

H5: Subjective norms have a significant influence on preschool teachers' intention to continue implementing STEM education activities.

There are various perspectives and different studies on the classification of reference groups. For example, Sadaf and Gezer (2020) categorized the entire relevant population into three reference groups: superiors, peers, and students; Shiue (2007) divided them into administrative support and peer use; while Santos and Okazaki (2013) focused solely on the influence of peer groups. In this study, we focus only on the two reference groups of peers (other teachers) and superiors, as these groups exert the most significant social influence on teachers' professional decisions, whereas inferiors (students) generally do not have a substantial impact on preschool teachers' instructional choices. This approach ensures that our model accurately reflects the most relevant social influences on teachers' subjective norms in the context of STEM education. Additionally, Taylor & Todd's study suggests that these reference groups can influence adjustments to an individual's subjective norms. Therefore, the following hypotheses are proposed:

H6: The point of view of the students on STEM education has a significant influence on the subjective norms of the teachers.

H7: The viewpoint of the superiors about STEM education has a significant influence on the subjective norms of the teachers.

3.4. Perceived Behavioral Control

Perceived behavioral control reflects belief about possibility to gain necessary capacity, resources and opportunities or perceptions of internal and external factors which can interfere with behavior performance (Ajzen, 1991). In this study, perceived behavioral control includes perceptions of internal and external limits of an individual teacher when maintaining STEM education activities. It has been pointed out that perceived behavioral control is decisive to the actual decision (Taylor & Todd, 1995). For example, through empirical investigations, Lin and Williams (2016) confirmed that greater perceived behavioral control is correlational to stronger intention to implement STEM education. Therefore, the following hypothesis is proposed:

H8: Teachers' perceived behavioral control over STEM education has significant influence on preschool teachers' intention to continue implementing STEM education activities.

The DTPB model classifies perceived behavioral control into internal and external attachments, including specific expressions of self-efficacy, resources and technical factors. In this research study, teacher self-efficacy reflects teacher's self-assessment of their ability to complete STEM education training courses, reflecting their confidence in maintaining STEM education activities. Greater teacher's self-efficacy leads to greater behavioral intention (Taylor & Todd, 1995). Some previous research states that teacher self-efficacy is the strongest indicator of teacher intention. In addition, facilitating conditions refer to technological support (such as computers and STEM-related software), material and financial resources (such as laboratory equipment and instructional materials), and institutional support (such as school policies and professional development programs). These external factors ensure that teachers have the necessary tools and support to effectively implement STEM education activities. The lack of convenience in any of these aspects can create barriers, negatively influencing teacher BI (Taylor & Todd, 1995). Therefore, we propose the following hypotheses:

H9: The self-efficacy of teachers with STEM education has a significant influence on their perceived behavioral control.

H10: Teachers' positive facilitating conditions for STEM education have significant influence on their perceived behavioral control.

4. Methodology

To examine the factors that affect the intention of Vietnamese preschool teachers to continue to implement STEM / STEAM education activities, thus proposing appropriate solutions and policies to organise STEM education activities for teachers, the current research develops and uses research tools including a survey questionnaire with 02 main sections. Section 1 consists of 07 questions on demographic information of the survey respondents including: gender, teaching experience, qualifications, school, type of school, participation in STEM/STEAM education training programs, experience in organizing STEM/STEAM education activities. Section 2 consists of 52 items using the 5-point Linkert scale (from 1-strongly disagree to 5- strongly agree). The items are adapted from the DTPB model developed by Taylor and Todd (1995) with content revised based on the study by Wu et al. (2022) to match the subject and objectives of the current study. The questionnaire was translated from English to Vietnamese with the back translation technique to ensure the equivalence of the meaning of each item between the two versions. Before the official survey, the researchers conducted a pilot interview with 30 Vietnamese preschool teachers to verify the meaning and clarity of the questionnaire. Based on the feedback from the piloting stage, we reviewed and revised to create the final version of the questionnaire.

The survey subjects are in-service preschool teachers in Vietnam. To ensure a representative survey sample with a wide coverage of the population, the research adopted the stratified sampling method based on strata. Specifically, the author recruited participants based on (1) geographic area where teachers work (including mountainous, rural, urban areas); (2) type of school (including state, private, and individual-funded preschools); (3) teaching experience (from 5 years to more than 20 years). After determining the survey sample, the online Google form-based questionnaires were sent to the participants for responding within the duration of 02 weeks (from 1 May 2024 to 15 May 2024).

From the initial 1416 responses, after screening and eliminating incomplete responses (those with lack of required information, inaccurate responses, etc.), there were 1278 responses eligible for data analysis. The data was coded and keyed in the Excel software, SPSS 27 software, and AMOS 24 for analyzing. Specifically, this study employed a scale designed based on the DTPB model; therefore, we used a Confirmatory Factor Analysis CFA with indices suitable for the overall design of the research to evaluate the suitability of the measurement model. Due to the large sample size, we deployed the indices with the following cut-off values: Chi-square/df index: <3: good; <5: satisfactory (Hair, Anderson, Babin & Black, 2010; Hu & Bentler, 1999; West, Taylor & Wu, 2012); CFI, GFI ≥ 0.95: very good, CFI, GFI ≥ 0.9 good, CFI, GFI ≥ 0.8 satisfactory (Baumgartner & Homburg, 1996; Doll, Xia & Torkzadeh, 1994; Hair et al., 2010; Hu & Bentler, 1999); TLI > 0.9: good (Hair et al., 2010) and RMSEA ≤ 0.08 good, RMSEA ≤ 0.03 good (Hair et al., 2010; Hu & Bentler, 1999). To evaluate the convergence of the constructs in the model, the author employed factor loading analysis on the items in the construct (> 0.5) (Hair et al., 2010). The study also examines the reliability of each construct based on the composite reliability index > 0.6 (Hair et al., 2010). Finally, the researchers used SEM linear structural model analysis to confirm the proposed hypothesis, with statistical significance < 0.05.

5. Results

5.1. Descriptive Statistics of the Research Sample

The statistics of the teachers surveyed show a gender disparity. Specifically, in the total of 1278 respondents, there were only 6 male teachers (accounting for 0.5% of all the respondents), and 1272 female teachers (99.5%). This is a basic trait stemming from the tendency in pedagogic career choice in Vietnam, in which female gender is always dominant, particularly in preschool education level (Vietnam Ministry of Education and Training, 2020). Regarding teaching experience, teachers with less than 10 years of experience constituted the majority of the sample, accounting for a combined 53.0% —with 27.2% having under 5 years and 25.8% having between 5 and 10 years. This indicates a relatively young teaching workforce in the study. Meanwhile, those with over 15 years of experience— including 12.8% with 15–20 years and 12.9% with more than 20 years —made up 25.7% of the participants. Teachers with 10 to 15 years of experience represented 21.3% of the sample. Notably, the group with less than 5 years of teaching experience was the largest, slightly surpassing others. These figures seem to positively signify the growing attraction of preschool teacher careers with university graduates in Vietnam recently.

Regarding the type of preschool where participants were employed, the majority (83.5%) worked at public institutions, highlighting the predominant role of public preschools in Vietnam's early childhood education landscape. Meanwhile, 14.5% of respondents were from individual-funded preschools, and only 2.0% worked at private preschools. This distribution aligns with the national context, in which public preschools vastly outnumber their non-public counterparts in scale and accessibility.

The researchers included two survey questions to explore teachers' experience organizing STEM education activities and participating in STEM/STEAM training programs at the preschool level. The results show that 998 teachers, accounting for 78.1% of all respondents, had received training in STEM/STEAM education —either theoretical or a combination of theory and practice. This proportion accurately reflects the current efforts in Vietnam to provide professional development opportunities for teachers in integrated STEM/STEAM instruction. Since 2019, with the implementation of various training programs in different formats, the number of teachers receiving formal training related to curriculum reform and modernization has steadily increased.

However, among the 998 teachers who had received STEM/STEAM training, 66.7% had only implemented STEM education activities once or twice, 12.9% had done so 2 to 4 times, and 20.4% had organized such activities more than 5 times. Notably, even among teachers without formal training, some reported having organized STEM education activities at least once or twice.

5.2. Evaluation of the Measurement Model with CFA

The CFA Confirmatory Factor Analysis yielded the standardised analysis results: All indices are above the cut-off values, indicating the strong fit between the model and the collected dataset: Chi-square/df < 3, with Sig. (p-value) < 0.05, which is statistically significant; GFI, TLI, CFI > 0.9 and RMSEA <0.06. Meanwhile, all factor loadings were greater than 0.5, which implies the convergence of the factors in the model. In addition, the researchers calculated composite reliability and total variation explained to test the reliability of the scales. It is found that the composite reliability was greater than 0.7 vs. the total variance explained of all the factors > 0.5, which means that the factors are reliable enough to proceed with data analysis.

No.	Index	Estimate
1	Chi-square/df	2.963
2	p-value of Chi-square	0.000
3	GFI	0.902
4	CFI	0.953
5	TLI	0.949
6	RMSEA	0.039

Table 1. Indices for evaluating CFA results according to standardised coefficients

No.	Item Relationship			Factor loading (CFA)	Composite Reliability	Total Variance Explained
1	AT3	←	AT	0.867	0.919	0.70
2	AT1	←	AT	0.875		
3	AT4	←	AT	0.893		
4	AT2	←	AT	0.908		
5	AT5	←	AT	0.589		
6	PU3	←	PU	0.854	0.892	0.63
7	PU2	←	PU	0.845		
8	PU5	←	PU	0.761		
9	PU1	←	PU	0.807		
10	PU4	←	PU	0.674		
11	PEU2	←	PEU	0.889	0.906	0.71
12	PEU3	←	PEU	0.84		
13	PEU1	←	PEU	0.826		
14	PEU4	←	PEU	0.804		
15	CO3	←	CO	0.866	0.898	0.64
16	CO4	←	CO	0.86		
17	CO1	←	CO	0.834		
18	CO5	←	CO	0.767		
19	CO2	←	CO	0.65		
20	SN1	←	SN	0.879	0.908	0.77
21	SN2	←	SN	0.906		
22	SN3	←	SN	0.843		
23	PEI2	←	PEI	0.857	0.938	0.75
24	PEI4	←	PEI	0.891		
25	PEI1	←	PEI	0.845		
26	PEI5	←	PEI	0.889		
27	PEI3	←	PEI	0.853		
28	SUI2	←	SUI	0.884	0.920	0.70

No.	Item Relationship			Factor loading (CFA)	Composite Reliability	Total Variance Explained
29	SUI3	←	SUI	0.872		
30	SUI4	←	SUI	0.823		
31	SUI1	←	SUI	0.867		
32	SUI5	←	SUI	0.725		
33	PBC2	←	PBC	0.838	0.925	0.71
34	PBC3	←	PBC	0.871		
35	PBC1	←	PBC	0.789		
36	PBC4	←	PBC	0.85		
37	PBC5	←	PBC	0.867		
38	SE2	←	SE	0.694	0.84	0.5
39	SE1	←	SE	0.70		
40	SE4	←	SE	0.658		
41	SE6	←	SE	0.756		
42	SE5	←	SE	0.687		
43	SE3	←	SE	0.618		
44	FC4	←	FC	0.854	0.886	0.66
45	FC3	←	FC	0.829		
46	FC2	←	FC	0.801		
47	FC1	←	FC	0.767		
48	BI3	←	BI	0.884	0.911	0.72
49	BI2	←	BI	0.869		
50	BI4	←	BI	0.826		
51	BI5	←	BI	0.81		
52	BI1	←	BI	0.768		

Table 2. Indices to evaluate the reliability and convergence of the scale

5.3. Evaluating the Construct Model

The CFA results confirm that the measurement model is fit enough for the analysis of the SEM linear construct model. There are 11 main factor groups: AT (Attitudes), PU (Perceived usefulness), PEU (Ease of use), CO (Compatibility), SN (Subjective norms), PEI (Peer influence), SUI (Superior influence), PBC (Perceived behavioral control), SE (Self-efficacy), FC (Facilitating conditions), BI (Intention to continue implementing STEM education). To perform the analysis of the SEM linear construct model to examine the relationships between factors, the researchers transformed the model retrieved from the CFA results into a SEM construct model. After analyzing, the standardized SEM linear construct model results are presented below:

It can be seen from Figure 6 that the results of the construction model fit the survey data, which is illustrated with the indices such as: Chi square / df = 4.448 < 5, with p-value = 0.000 < 0.05, this is statistically significant; GFI = 0.865 > 0.8: satisfactory; TLI = 0.910 > 0.9: good, CFI = 0.916 > 0.9: good, and RMSEA = 0.052 < 0.06: good, PCLOSE = 0.011 > 0.01.

Figure 2 shows that the p-values of the relationship between the factors as follows: The PU factor is statistically significant in influencing AT as the p-value of this relationship is 0.000 < 0.05; The PEU and CO are not statistically significant in influencing AT as the p-value of these relationships is 0.423 and 0.728 > 0.05; SUI is statistically significant in influencing SN as the p-value of this relationship is 0.000 < 0.05; PEI is not statistically significant in influencing SN as the p-value of this relationship is 0.275 > 0.05; SE, FC are statistically significant in influencing PBC as the p-value of these relationships is 0.000 < 0.05; AT, SN, PBC are statistically significant in influencing BT as the p-value of these relationships is 0.009, 0.002, 0.000 < 0.05.

Regarding the regression coefficients between the factors, their values are all > 0, which indicates a positive relationship (positive effect) between the factors. It can also be seen that, of all the 3 factors directly affecting BI (the intention to continue implement STEM education activities), PBC (teachers' perceived behavioral control with STEM education, including: teacher self-efficacy in STEM education and STEM education facilitating conditions) has the greatest influence, followed by SN (subjective norms) and AT (Teachers' Attitude/Emotional Readiness for STEM education).

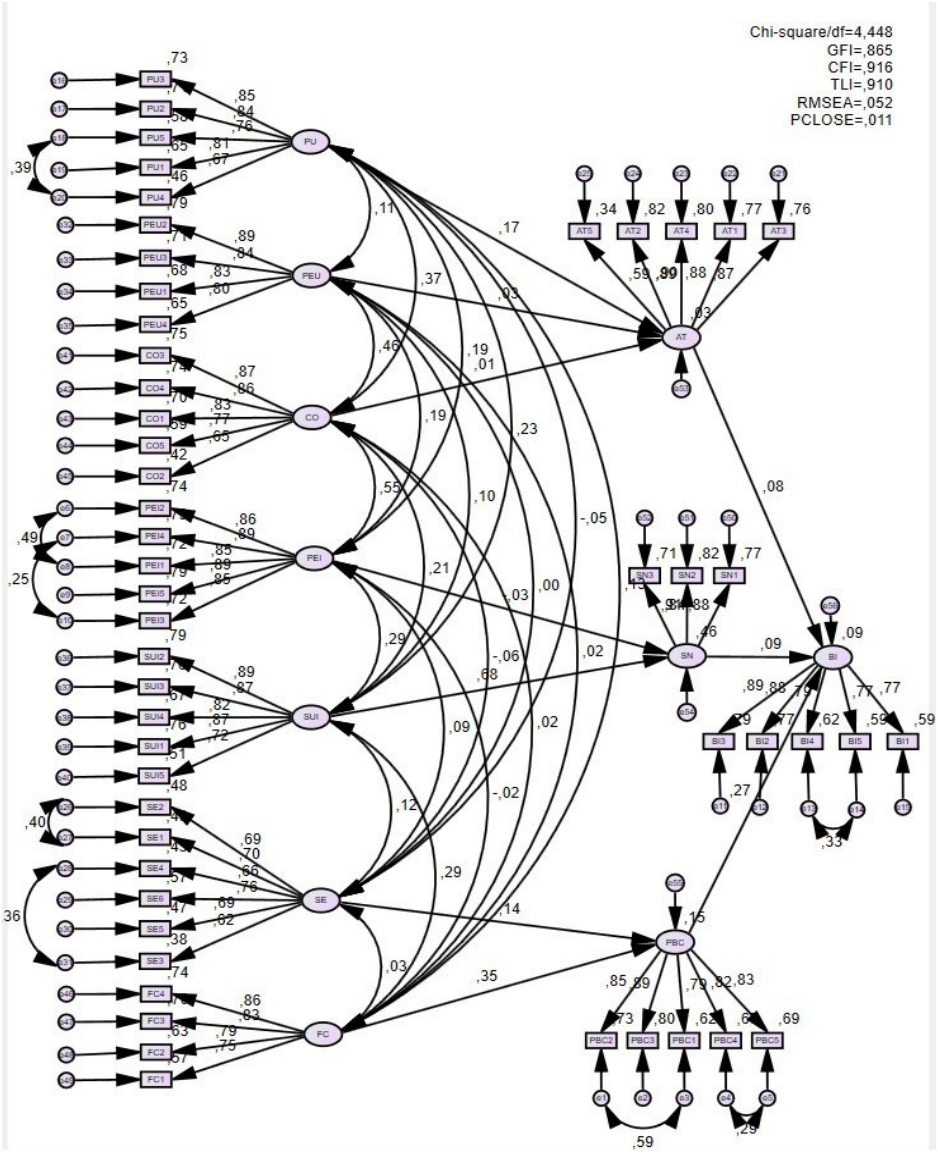


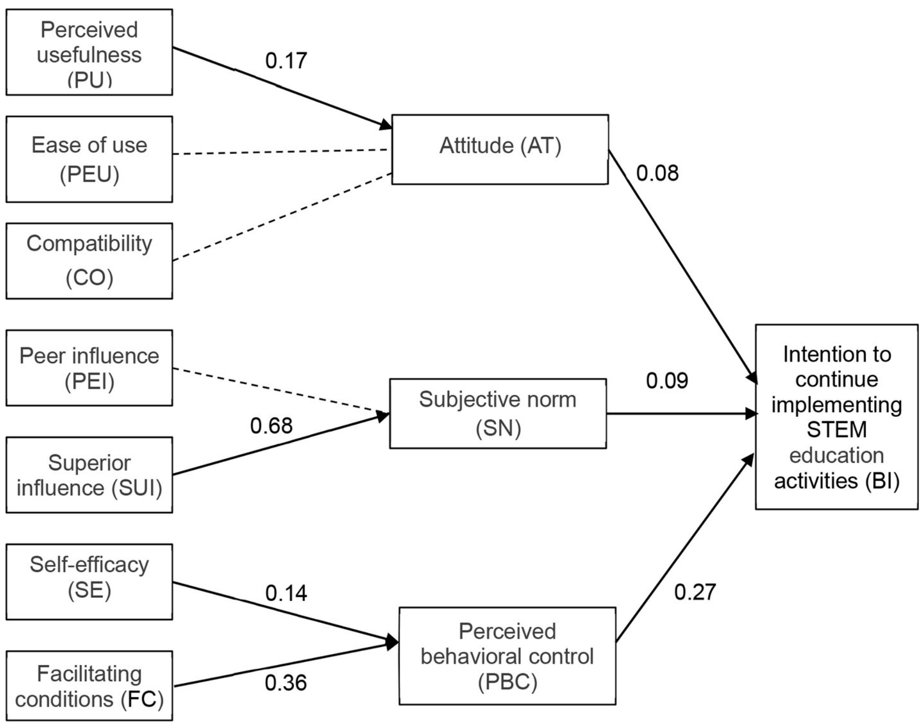
Figure 2. The construct model result (SEM) showing the factor relationships (with standardised coefficients)

Hypothesis	Relationship	Regression Coefficients	S.E.	C.R.	P	Conclusion
H2	AT ← PU	0.17	0.034	4.985	***	Accepted
H3	AT ← PEU	0.03	0.029	0.802	0.423	Rejected
H4	AT ← CO	0.01	0.035	0.348	0.728	Rejected
H6	SN ← PEI	-0.03	0.027	-1.091	0.275	Rejected
H7	SN ← SUI	0.68	0.031	24.091	***	Accepted
H9	PBC ← SE	0.14	0.031	4.401	***	Accepted
H10	PBC ← FC	0.36	0.026	11.683	***	Accepted
H1	BI ← AT	0.08	0.027	2.609	0.009	Accepted
H5	BI ← SN	0.09	0.025	3.159	0.002	Accepted
H8	BI ← PBC	0.27	0.032	8.909	***	Accepted

Note: *** mean 0.000 or 0%

Table 3. Results of SEM linear regression model of the factors based on regression coefficients

It can be concluded from Table 3 that the hypotheses H3, H4, H6 are rejected while the remaining H1, H2, H5, H7, H8, H9, H10 are accepted. (Table 3, Figure 3).



Note: the dashed line indicates a rejected hypothesis (with no influence)

Figure 3. Results of the construct model regarding the influence of the factors

6. Discussion

Teachers' intention to continue implementing STEM education activities plays a crucial role in the successful implementation of these activities in preschools. Previous studies assert that teachers' intentions reflect the level of their commitment and motivation, ensuring that they will dedicate time and effort to preparing and carrying out these activities effectively (Brown & Bogiages, 2019). This commitment helps to maintain consistency and sustainability in the teaching syllabus, which is essential to developing STEM / STEAM skills in children over time. Additionally, teachers who have positive intentions can create an attractive learning environment and various learning opportunities for children, including creative lessons and practical activities, encouraging children's engagement. Children usually react more positively when teachers demonstrate their enthusiasm and passion (English, 2017; Thibaut, Knipprath, Dehaene & Depaepe, 2018). However, this study represents one of the preliminary efforts to explore the factors influencing preschool teachers' intentions to sustain STEM/STEAM education activities, particularly in the Vietnamese context.

It is crucial to acknowledge that the factors affecting teachers' intentions to adopt STEM/STEAM education might differ considerably in different cultural and educational environments. In the case of Vietnam, where STEM/STEAM education is relatively new and encounters specific obstacles like a lack of teacher training and adherence to traditional teaching preferences (Dinh, 2021; Bui et al., 2023), the role of subjective norms, self-efficacy, and perceived utility might differ in comparison to more developed STEM/STEAM settings like the USA or Western Europe. For example, in Western nations, teachers might have more readily available resources and opportunities for professional development, which could increase their self-efficacy and perceived utility of STEM/STEAM education (Papadakis & Kalogiannakis, 2020; Nikolopoulou, 2023). Papadakis and Kalogiannakis (2020) discovered that preservice Greek preschool teachers exhibit favorable attitudes toward using educational robots in preschool education and report high perceived utility and possibly high self-efficacy in using robots with appropriate training. In Vietnam, the absence of similar support systems reinforces lower self-efficacy and perceived utility among preschool teachers (Bui et al., 2023). Therefore, while our study identifies perceived behavioral control as a key factor, future research should explore how these factors interact differently in various cultural settings.

The research results show that only 7 of the 10 proposed hypotheses were accepted among Vietnamese preschool teachers, while three were rejected (Table 3). The most influential factor is teachers' Perceived Behavioral Control (PBC) over STEM/STEAM education, encompassing self-efficacy and facilitating conditions. Our findings highlight perceived behavioral control as the most influential factor in Vietnamese preschool teachers' intention to maintain STEM/STEAM education, consistent with studies in China (Wu et al., 2022) and Taiwan (Lin & Williams, 2016). However, this contrasts with Wijaya et al. (2022), who found no direct influence of perceived behavioral control on Indonesian preservice teachers' intentions. These discrepancies underscore the context-specific nature of these factors. In Vietnam, where STEM/STEAM is less established, perceived behavioral control might play a more critical role due to the novelty and challenges associated with implementing these activities. Wu et al. (2022) used the Decomposed Theory of Planned Behavior (DTPB) to identify factors affecting high school teachers' intentions in China, while Lin and Williams (2016) applied the Theory of Planned Behavior (TPB) to explore behavioral intentions among Taiwanese preservice science teachers. Although the research models differ slightly, all three studies evaluated Attitudes (AT), Subjective Norms (SN), and PBC. In our study, all three factors influence teachers' intentions to maintain STEM/STEAM activities to varying degrees. In contrast, Wu et al. (2022) and Lin and Williams (2016) found that AT had no effect. Conversely, Wijaya et al. (2022) concluded that none of the three factors directly influenced Indonesian preservice secondary school teachers' intentions. To strengthen our understanding, future research could incorporate cross-national comparisons, examining how perceived behavioral control and other factors influence teachers' intentions in different cultural and educational contexts.

Regarding factors with indirect influence, in this study, the factors with the greatest indirect influence on the intention of Vietnamese preschool teachers to maintain STEM education activities are superior influence vs. facilitation conditions. This finding is different from that of Wu et al. (2022), who concluded that perceived usefulness and self-efficacy have the greatest indirect influence. However, the finding of this paper can be justified with the role of the superiors in shaping the school culture and guiding the school's development. When school leaders place a high value on STEM/STEAM education and its significance, teachers' perceptions and behaviors are greatly influenced. Eventually, teachers would engage in and maintain STEM/STEAM education activities. Superior support includes creating facilitating conditions such as time, materials, and recognition of teachers' efforts, which are critical for implementation. The significance of school support and teacher training in sustaining STEM/STEAM education is well-documented in the literature. In developed countries, comprehensive professional development programs and institutional support are key to teachers successfully integrating

STEM/STEAM into their curricula (Fridberg et al., 2023; Demircan, 2022). For example, in Greece, preservice teachers have shown positive attitudes toward educational robotics but require adequate training to build their self-efficacy (Papadakis & Kalogiannakis, 2020). In contrast, the lack of such support systems in Vietnam contributes to teachers' hesitation and lower intention to maintain these activities (Bui et al., 2023). Our findings reinforce the need for targeted interventions to enhance school support and teacher training in Vietnamese preschools, potentially drawing from successful models in Western countries.

Dinh (2021) noted that in Vietnam, only 62.5% of surveyed school managers and 8% of preschool teachers were aware of STEM education. Many teachers, particularly those from minority ethnic groups or with over 15 years of experience, felt unprepared due to the novelty of STEM/STEAM education. Consequently, factors like self-efficacy and perceived usefulness indirectly influence teachers' intentions. Low self-efficacy or perceived incompetence can demotivate teachers, reducing their willingness to continue. To address this, recent studies suggest that practical, hands-on training programs can significantly improve teachers' self-efficacy and confidence in STEM/STEAM teaching (Fridberg et al., 2023). For instance, Nikolopoulou (2023) highlights that digital games and interactive tools can enhance teachers' engagement with STEM/STEAM, provided they receive adequate training. In Vietnam, where teachers often revert to traditional methods (Shaw et al., 2021), such programs could bridge the gap between theoretical knowledge and practical application, fostering greater intention to sustain STEM/STEAM activities.

Our findings also indicate that perceived ease of use (Hypothesis 3) does not influence Vietnamese preschool teachers' attitudes toward maintaining STEM/STEAM activities. Similarly, teachers' anxiety (Hypotheses 4 and 6) does not affect their preferences for applying STEM/STEAM education, their implementation, or their belief in its value. Teachers view STEM/STEAM as an exciting opportunity with significant benefits for students, outweighing concerns about ease of use or anxiety. This suggests that their positive attitudes stem from the perceived value and benefits of STEM/STEAM rather than its challenges. This aligns with findings from Western contexts, where teachers' enthusiasm for STEM/STEAM is driven by its potential to engage students creatively despite initial difficulties (Sariçam & Yildirim, 2021).

Recent studies from Western countries have provided valuable insights regarding technology integration in STEM/STEAM education. For instance, in the USA and Australia, touchscreen technology and digital games have effectively enhanced STEM learning in preschool settings (Aladé, Lauricella, Beaudoin-Ryan & Wartella, 2016; Sariçam & Yildirim, 2021). Similarly, in Greece, educational robotics have been explored as a tool for STEM education, with positive attitudes from preservice teachers (Papadakis & Kalogiannakis, 2020). While technology is recognized as a facilitator in Vietnam, its integration is hindered by teachers' limited familiarity and confidence with these tools (Evagorou, 2024). Therefore, professional development programs should include training on technology use to boost teachers' self-efficacy and perceived utility of STEM/STEAM education. This highlights the resilience of Vietnamese preschool teachers, who are willing to confront challenges to achieve broader educational goals.

7. Conclusion and Recommendations

Based on the SEM construct model, the study verifies the hypotheses with 07 accepted and 03 rejected. The rejected hypotheses include 02 regarding the influence of perceived ease of use and compatibility on teachers' attitudes towards maintaining STEM education activities and 01 regarding the influence of Peer influence on teachers' Subjective norms. The accepted hypotheses address: the positive influence of attitudes, subjective norms and perceived behavioral control on preschool teachers' intention to keep carrying out STEM education activities; the positive influence of perceived usefulness on teachers' Attitudes towards maintaining STEM education activities; the positive influence of Superior influence on teachers' Subjective norms; the positive influence of self-efficacy and facilitating conditions on teachers' perceived behavioral control.

The study has drawn some preliminary conclusions on the factors affecting the intention of continue implementing STEM education activities of preschool teachers in Vietnam, such as perceived behaviour control, self-efficacy, and attitude. It should be noted that perceived behaviour control is found to be influential in maintaining SEA by teachers. This underscores the influence of Superiors and the facilitation of conditions as two important factors in creating a favourable environment and motivation for preschool teachers in Vietnam to continue implementing STEM education activities. The support of school leaders and the facilitation conditions build the teacher's feeling of being supported, confident, and motivated to overcome difficulties and obstacles in the implementation of STEM / STEAM education.

However, some limitations and obstacles to implementing STEM/STEAM education in preschools are also revealed. A noticeable limitation lies in the attitudes and emotional readiness of teachers for STEM/STEAM education. Despite efforts to train teachers and support them to improve professional competency, some teachers are not willing and active enough to continue to implement SEA after attending training programmes. Regarding this issue, while perceived ease of use or compatibility does not influence teachers' intention, perceived usefulness is found to have some influence on teachers' readiness.

The research results can contribute to determining appropriate solutions and policies to promote the implementation of SEA in preschools in Vietnam, in particular, and other countries with similar conditions as well. It can be seen from the preliminary findings that to foster the intention to maintain SEA of preschool teachers in Vietnam, it is essential to take specific measures regarding two main influential factors: Superior Influence and Facilitating Conditions. To be more specific:

i. Enhancing support and commitment from schools leaders, including: introducing relevant policies and programmes involving school leaders and encouraging their engagement in the STEM/STEAM education programmes and workshops, or experience sharing session to gain deeper insights into STEM/STEAM education; thereby issuing consistent direction to promote STEM education in school and create favorable conditions, establish transparent policies and regulations for punishment and rewarding to encourage teachers to engage in and maintain SEA, such as rewarding teachers with outstanding achievements in STEM/STEAM implementation.

ii. Regarding teacher training activities, it is advisable to focus on increasing teachers' awareness of Perceived Usefulness. In addition to previously taken measures, such as emphasising the benefits of STEM/STEAM education, it is necessary to promote different ways to share success stories and create an environment for practice and real-life application in training programs.

8. Limitations

This study has several limitations that should be acknowledged. First, the data were collected using a self-reported questionnaire, which may be subject to social desirability bias or differences in participants' interpretation of the items. Second, although the sample size was relatively large and diverse regarding geography and teaching experience, all participants were Vietnamese preschool teachers. This limits the generalizability of the findings to other cultural or educational contexts. Third, some constructs—such as perceived ease of use and peer influence—showed weak or non-significant relationships with behavioral intention. While we have discussed potential cultural and contextual reasons for these results, it is also possible that the measurement tools did not fully capture how these constructs operate in the Vietnamese preschool setting. Future studies may benefit from refining or adapting these measures through qualitative pretesting or mixed-method designs. Finally, the study focuses primarily on individual-level factors. Broader structural and policy-level influences—such as leadership practices, school culture, or national curriculum frameworks—were beyond the scope of this research but may also play a significant role in shaping teachers' long-term engagement with STEM/STEAM education. These aspects warrant further investigation in future studies.

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References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Aladé, F., Lauricella, A.R., Beaudoin-Ryan, L., & Wartella, E. (2016). Measuring with Murray: Touchscreen technology and preschoolers' STEM learning. *Computers in Human Behavior,* 62, 433-441. https://doi.org/10.1016/j.chb.2016.03.080

Aldemir, J., & Kermani, H. (2017). Integrated STEM curriculum: improving educational outcomes for Head Start children. *Early Child Development and Care,* 187(11), 1694-1706. https://doi.org/10.1080/03004430.2016.1185102

Aranda, G., Campbell, C., Ferguson, J., & Speldewinde, C. (2022). Introducing Digital Technologies into Play-Based Learning in Early Childhood. In *Lecture Notes in Educational Technology* (525-551). https://doi.org/10.1007/978-981-19-0568-1_22

Baumgartner, H., & Homburg, C. (1996). Applications of structural equation modeling in marketing and consumer research: A review. *International Journal of Research in Marketing,* 13(2), 139-161.

Brown, R.E., & Bogiages, C.A. (2019). Professional Development Through STEM Integration: How Early Career Math and Science Teachers Respond to Experiencing Integrated STEM Tasks. *International Journal of Science and Mathematics Education,* 17(1), 111-128. https://doi.org/10.1007/s10763-017-9863-x

Bui, T.L., Tran, T.T., Nguyen, T.H., Nguyen-Thi, L., Tran, V.N., Dang, U.P. et al. (2023). Dataset of Vietnamese preschool teachers' readiness towards implementing STEAM activities and projects. *Data in Brief,* 46, 108821. https://doi.org/10.1016/j.dib.2022.108821

Chen, Y.L., Huang, L.F., & Wu, P.C. (2021). Preservice Preschool Teachers' Self-efficacy in and Need for STEM Education Professional Development: STEM Pedagogical Belief as a Mediator. *Early Childhood Education Journal,* 49(2), 137-147. https://doi.org/10.1007/s10643-020-01055-3

Chen, Y.L., & Tippett, C.D. (2022). Project-Based Inquiry in STEM Teaching for Preschool Children. *Eurasia Journal of Mathematics, Science and Technology Education,* 18(4), em2093. https://doi.org/10.29333/ejmste/11899

Cheng, M.M.H., Buntting, C., & Jones, A. (2022). Concepts and Practices of STEM Education in Asia. In Cheng, M.M.H., Buntting, C., & Jones, A. (Eds.), *Concepts and Practices of STEM Education in Asia.* Springer Nature Singapore. https://doi.org/10.1007/978-981-19-2596-2

Chibisa, A., & Mutambara, D. (2022). An exploration of STEM students' and educators' behavioral intention to use mobile learning. *Journal of E-Learning and Knowledge Society,* 18(3), 166-176. https://doi.org/10.20368/1971-8829/1135622

Clements, D.H., & Sarama, J. (2016). Math, Science, and Technology in the Early Grades. *The Future of Children,* 26(2), 75-94. https://doi.org/10.1353/foc.2016.0013

Davis, F.D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly,* 13(3), 319. https://doi.org/10.2307/249008

DeJarnette, N.K. (2018). Implementing STEAM in the Early Childhood Classroom. *European Journal of STEM Education,* 3(3). https://doi.org/10.20897/ejsteme/3878

Demircan, H.Ö. (2022). "How am I supposed to do this on my own?": A case study on perspectives of preschool teachers regarding integrative STEM practices. *Journal of Early Childhood Research,* 20(1), 93-112. https://doi.org/10.1177/1476718X211052749

Dinh, L.T. (2021). Difficulties in implementing STEAM education model at the Northern mountainous preschool in Vietnam. *Journal of Physics: Conference Series,* 1835(1), 012020. https://doi.org/10.1088/1742-6596/1835/1/012020

Do, TT., Hoang, K.C., Do, T., Trinh, T.P.T., Nguyen, D.N., Tran, T. et al. (2021). Factors Influencing Teachers' Intentions to Use Realistic Mathematics Education in Vietnam: An Extension of the Theory of Planned Behavior. *Journal on Mathematics Education,* 12(2), 331-348. https://doi.org/10.22342/jme.12.2.14094.331-348

Doll, W.J., Xia, W., & Torkzadeh, G. (1994). A confirmatory factor analysis of the end-user computing satisfaction instrument. *MIS Quarterly,* 453-461.

English, L.D. (2017). Advancing Elementary and Middle School STEM Education. *International Journal of Science and Mathematics Education,* 15, 5-24. https://doi.org/10.1007/s10763-017-9802-x

Evagorou, M. (2024). Engaging kindergarten pre-service teachers in the design and implementation of STEM lessons. *Frontiers in Education,* 9. https://doi.org/10.3389/feduc.2024.1277835

Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020). Understanding K-12 STEM education: A framework for developing STEM literacy. *Journal of Science Education and Technology,* 29, 369-385.

Fridberg, M., & Redfors, A. (2023). "But Then I am the Robot's Brain!": Children's and Preschool Teachers' Communication During STEM Teaching Scaffolded by Digital Tools. In *Science, Technology, Engineering, Arts, and Mathematics (Steam) Education in the Early Years: Achieving the Sustainable Development Goals* (108-119). Routledge. https://doi.org/10.4324/9781003353683-10

Fridberg, M., Redfors, A., Greca, I.M., & Terceño, E.M.G. (2023). Spanish and Swedish teachers' perspective of teaching STEM and robotics in preschool - results from the botSTEM project. *International Journal of Technology and Design Education,* 33(1), 1-21. https://doi.org/10.1007/s10798-021-09717-y

García-Sánchez, E.R., Candia-García, F., & Vargas-Martínez, H.S. (2024). A Techno-Pedagogical Framework for STEM Education Using Disruptive Innovations. *Lecture Notes in Networks and Systems,* 695, 161-170. https://doi.org/10.1007/978-981-99-3043-2_13

Greenwood, C.R., Irvin, D.W., Schnitz, A.G., & Buzhardt, J. (2024). Children's exposure to STEM instruction in preschool and how they respond to it. *Science Education,* 108(2), 524-545. https://doi.org/10.1002/sce.21846

Hair, J.F., Anderson, R.E., Babin, B.J., & Black, W.C. (2010). *Multivariate data analysis: A global perspective* (7). Upper Saddle River, NJ: Pearson.

Ham, M., Jeger, M., & Frajman-Ivković, A. (2015). The role of subjective norms in forming the intention to purchase green food. *Economic Research-Ekonomska Istraživanja,* 28(1), 738-748. https://doi.org/10.1080/1331677X.2015.1083875

Hapgood, S., Czerniak, C.M., Brenneman, K., Clements, D.H., Duschl, R.A., Fleer, M. et al. (2020). The importance of early STEM education. In *Handbook of research on STEM education* (87-100). Routledge.

Hien, P.T.T. (2018). Vietnam early childhood education. *International Handbook of Early Childhood Education,* 663-670.

Hu, L., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal,* 6(1), 1-55.

Katz, L. G. (2010). STEM in the early years. Early Childhood Research and Practice, 12(2), 11-19.

Larkin, K., & Lowrie, T. (2023). Teaching Approaches for STEM Integration in Pre- and Primary School: a Systematic Qualitative Literature Review. *International Journal of Science and Mathematics Education,* 21, 11-39. https://doi.org/10.1007/s10763-023-10362-1

Lange, A.A., Nayfeld, I., Mano, H., & Jung, K. (2022). Experimental effects of a preschool STEM professional learning model on educators' attitudes, beliefs, confidence, and knowledge. *Journal of Early Childhood Teacher Education,* 43(4), 509-539. https://doi.org/10.1080/10901027.2021.1911891

Lin, K.Y., & Williams, P.J. (2016). Taiwanese Preservice Teachers' Science, Technology, Engineering, and Mathematics Teaching Intention. In *International Journal of Science and Mathematics Education,* 4(6), 1021-1036. https://doi.org/10.1007/s10763-015-9645-2

Mesutoglu, C., & Corlu, M.S. (2023). The earlySTEM Program: An Evaluation Through Teacher Perceptions. *Canadian Journal of Science, Mathematics and Technology Education,* 23(1), 145-160. https://doi.org/10.1007/s42330-023-00264-3

Morgan, A., Smaldone, D., Selin, S., Deng, J., & Holmes, M. (2022). Adding relevancy to STEM interest through adventure education: A mixed methods study. *Interdisciplinary Journal of Environmental and Science Education*, 18(4), e2294. https://doi.org/10.21601/ijese/12214

Ndlovu, M., Ramdhany, V., Spangenberg, E.D., & Govender, R. (2020). Preservice teachers' beliefs and intentions about integrating mathematics teaching and learning ICTs in their classrooms. *ZDM,* 52(7), 1365-1380. https://doi.org/10.1007/s11858-020-01186-2

Nikolopoulou, K. (2022). Digital Technology in Early STEM Education: Exploring Its Supportive Role. In *Lecture Notes in Educational Technology* (103-115). https://doi.org/10.1007/978-981-19-0568-1_6

Nikolopoulou, K. (2023). STEM activities for children aged 4-7 years: teachers' practices and views. *International Journal of Early Years Education,* 31(3), 806-821. https://doi.org/10.1080/09669760.2022.2128994

Papadakis, S., Gözüm, A.İ.C., Kaya, Ü.Ü., Kalogiannakis, M., & Karaköse, T. (2024). Examining the Validity and Reliability of the Teacher Self-Efficacy Scale in the Use of ICT at Home for Preschool Distance Education (TSES-ICT-PDE) Among Greek Preschool Teachers: A Comparative Study with Turkey. In *EAI/Springer Innovations in Communication and Computing* (1-30). https://doi.org/10.1007/978-3-031-50139-5_1

Papadakis, S., & Kalogiannakis, M. (2020). Exploring Preservice Teachers' Attitudes About the Usage of Educational Robotics in Preschool Education. In *Handbook of Research on Tools for Teaching Computational Thinking in P-12 Education* (339-355). https://doi.org/10.4018/978-1-7998-4576-8.ch013

Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., Kalogiannakis, M., & Vassilakis, K. (2021). Factors That Hinder in-Service Teachers from Incorporating Educational Robotics into Their Daily or Future Teaching Practice. *CSEDU,* 2, 55-63.

Promkatkeaw, T., Seetee, N., & Dahsah, C. (2022). Fostering STEM Education for Early Childhood in Thailand. In *Concepts and Practices of STEM Education in Asia* (101-116). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-2596-2_6

Rasyid, A., Sugandi, M.K., Gaffar, A.A., Jatisunda, M.G., Santoso, E., & Nahdi, D.S. (2021). Teaching STEM through play in kindergarten: analysis towards pre-service early childhood teachers preparing the lesson plan. *Journal of Physics: Conference Series,* 1764(1), 012130. https://doi.org/10.1088/1742-6596/1764/1/012130

Rogers, R.R.H., Winship, J., & Sun, Y. (2015). Systematic support for STEM pre-service teachers: An authentic and sustainable four-pillar professional development model. In *Innovative Professional Development Methods and Strategies for STEM Education* (73-90). https://doi.org/10.4018/978-1-4666-9471-2.ch005

Ryu, M., Mentzer, N., & Knobloch, N. (2019). Preservice teachers' experiences of STEM integration: challenges and implications for integrated STEM teacher preparation. *International Journal of Technology and Design Education,* 29(3), 493-512. https://doi.org/10.1007/s10798-018-9440-9

Sadaf, A., & Gezer, T. (2020). Exploring factors that influence teachers' intentions to integrate digital literacy using the decomposed theory of planned behavior. *Journal of Digital Learning in Teacher Education*, 36(2), 124-145. https://doi.org/10.1080/21532974.2020.1719244

Santos, L.M.R.D., & Okazaki, S. (2013). Understanding E-Learning Adoption among Brazilian Universities: An Application of the Decomposed Theory of Planned Behavior. *Journal of Educational Computing Research*, 49(3), 363-379. https://doi.org/10.2190/ec.49.3.e

Sariçam, U., & Yildirim, M. (2021). The Effects of Digital Game-Based STEM Activities on Students' Interests in STEM Fields and Scientific Creativity: Minecraft Case. *International Journal of Technology in Education and Science,* 5(2), 166-192.

Shaw, P.A., Traunter, J.E., Nguyen, N., Huong, T.T., & Thao-Do, T.P. (2021). Immersive-learning experiences in real-life contexts: deconstructing and reconstructing Vietnamese kindergarten teachers' understanding of STEAM education. *International Journal of Early Years Education,* 29(3), 329-348. https://doi.org/10.1080/09669760.2021.1933920

Shiue, Y.-M. (2007). Investigating the Sources of Teachers' Instructional Technology Use Through the Decomposed Theory of Planned Behavior. *Journal of Educational Computing Research*, 36(4), 425-453. https://doi.org/10.2190/a407-22rr-50x6-2830

Simoncini, K., & Lasen, M. (2018). Ideas About STEM Among Australian Early Childhood Professionals: How Important is STEM in Early Childhood Education? *International Journal of Early Childhood,* 50(3), 353-369. https://doi.org/10.1007/s13158-018-0229-5

Speldewinde, C., & Campbell, C. (2023). 'Bush kinders': developing early years learners technology and engineering understandings. *International Journal of Technology and Design Education,* 33(3), 775-792. https://doi.org/10.1007/s10798-022-09758-x

Spyropoulou, C., Wallace, M., Vassilakis, C., & Poulopoulos, V. (2020). Examining the use of STEAM Education in Preschool Education. *European Journal of Engineering Research and Science,* December, 1-6. https://doi.org/10.24018/ejeng.2020.0.CIE.2309

Sun, F., Tian, P., Sun, D., Fan, Y., & Yang, Y. (2024). Pre□service teachers' inclination to integrate AI into STEM education: Analysis of influencing factors. *British Journal of Educational Technology,* 55(6). 2574-2596. https://doi.org/10.1111/bjet.13469

Tao, K.C., Hsieh, T.F., Hsu, C.Y., Yang, J.J., & Sia, W.Y. (2019). A Study on the Intention of Using Online E-Learning Platform to Assist in Teaching of Junior High School Teachers. *Proceedings of the 2019 3rd International Conference on Education and Multimedia Technology (ICEMT 2019)* (41-44). https://doi.org/10.1145/3345120.3345194

Taylor, S., & Todd, P.A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research,* 6(2), 144-176.

Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers and Education,* 57(4), 2432-2440. https://doi.org/10.1016/j.compedu.2011.06.008

Thibaut, L., Knipprath, H., Dehaene, W., & Depaepe, F. (2018). The influence of teachers' attitudes and school context on instructional practices in integrated STEM education. *Teaching and Teacher Education,* 71, 190-205. https://doi.org/10.1016/j.tate.2017.12.014

Vietnam Ministry of Education and Training (2020). *Sô liêu chung vê dào tao giáo viên trình dô cao dang năm hoc 2018-2019 [General data on training college-level teachers in the academic year 2018-2019]*. Available at: https://moet.gov.vn/thong-ke/Pages/dao-tao-giao-vien-cao-dang.aspx?ItemID=6637

Wang, X., Abdul-Rahman, M.N.B., & Nizam-Shaharom, M.S. (2024). The impacts of augmented reality technology integrated STEM preschooler modules for teaching and learning activity on children in China. *Cogent Education,* 11(1). https://doi.org/10.1080/2331186X.2024.2343527

West, S.G., Taylor, A.B., & Wu, W. (2012). Model fit and model selection in structural equation modeling. *Handbook of Structural Equation Modeling,* 1(1), 209-231.

Wijaya, T.T., Jiang, P., Mailizar, M., & Habibi, A. (2022). Predicting Factors Influencing Preservice Teachers' Behavior Intention in the Implementation of STEM Education Using Partial Least Squares Approach. *Sustainability (Switzerland),* 14(16). https://doi.org/10.3390/su14169925

Wu, P., Yang, L., Hu, X., Li, B., Liu, Q., Wang, Y. et al. (2022). How K12 Teachers' Readiness Influences Their Intention to Implement STEM Education: Exploratory Study Based on Decomposed Theory of Planned Behavior. *Applied Sciences,* 12(23), 11989. https://doi.org/10.3390/app122311989

Yelland, N. (2021). STEM Learning Ecologies: Productive Partnerships Supporting Transitions from Preschool to School Growing a Generation of New Learners. In *Embedding STEAM in Early Childhood Education and Care* (237-260). Springer International Publishing. https://doi.org/10.1007/978-3-030-65624-9_12

Yelland, N., & Waghorn, E. (2023). STEM learning ecologies: collaborative pedagogies for supporting transitions to school. *International Journal of Early Years Education,* 31(1), 216-235. https://doi.org/10.1080/09669760.2020.1863193

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