The Utilization of Simulation Technology by Malaysian Pre-Service Teachers and the Influencing Factors on their Decision Making: An Adaptation of the Unified Theory of Acceptance and Use of Technology (UTAUT)

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Abstract: Simulation technology has opened new avenues for the transformation of education by providing immersive and interactive learning experiences. This technology encompasses a variety of applications, from virtual classrooms to training simulations, that are proven to enhance learning, engagement, and retention. However, several researchers have indicated that pre-service teachers' acceptance of integrated simulation technology remains uncertain. Recognizing the significance of prior research, this study aims to find out current usage and factors that might influence Malaysian pre-service teachers' decision to integrate simulation technology into their teaching practices. The Unified Theory of Acceptance and Use of Technology (UTAUT) was adapted as the theoretical framework of this study. Data have been collected from 256 pre-service teachers and analyzed using descriptive statistics and Partial Least Square (PLS) regression of Structural Equation Modelling (SEM). The results indicated that the current utilization of simulation technology among Malaysian pre-service teachers is at a moderate level. The present study also suggested that pre-service teachers' facilitating conditions are the main predictor that influences pre-service decisions to integrate simulation technology. Based on these findings, a proposed model of simulation technology integration among Malaysian pre-service teachers is presented and the implications for theory development, practices, and policy-making are discussed.

Keywords: Pre-service Teachers, Simulation technology, Unified Theory of Acceptance and Use of Technology (UTAUT)

1. Introduction

Simulation technology has emerged as a transformative tool in teacher education, particularly in the preparation of pre-service teachers. This technology encompasses virtual classrooms, artificial intelligence (AI) driven student avatars, and mixed-reality teaching environments that replicate real-world challenges (Zhao, Dai & Chen, 2024). By providing immersive, risk-free, and interactive environments, simulation technology allows pre-service teachers to develop critical thinking skills, experiment with pedagogical strategies, and receive real-time feedback (Levin, Herni & Kasperski, 2025). Simulation technology also provides opportunities for experiential learning, allowing pre-service teachers to gain confidence, enhance classroom management skills, and formulate institutional strategies (Flavian & Levin, 2024) without the immediate pressures of a live classroom. Additionally, simulation-based training enhances pre-service teachers' capabilities to meet diverse student needs, manage behavioral issues, and effectively implement differentiated instruction (Ismail, 2024). The advancement of simulation technology is also poised to shape future educational practices by facilitating ongoing professional development, enabling data-driven teaching interventions, and fostering adaptive learning environments (Levin, 2024). Due to those uniqueness and advantages, simulation-based learning may become an essential component for pre-service teachers in leading toward more effective and technologically proficient educators.

The increasing integration of simulation technology into global educational settings has sparked ongoing efforts of the Malaysian Ministry of Education to ensure teachers' readiness to integrate simulation technology into the teaching and learning process. Various policies and initiatives have continuously been implemented through teacher training and professional development programs, aiming to enhance teachers teaching competencies and adaptation to the current educational demands (Tai, Khalip & Omar, 2022), including simulation technologies. However, although simulations offer a secure economical, and interactive educational experience, several challenges persist, including limited access, lack of instructor expertise, technical difficulties, and concerns regarding the applicability of these simulations to the real context. Additionally, the question remains about whether simulated experiences can adequately replace hands-on training, especially in fields that require physical manipulation and real-world problem-solving is still debatable (Levin, Frei-Landau & Goldberg, 2025). Moreover, learners' engagement and adaptability to simulated-based learning vary, raising concerns about whether this technology is equally effective for all learners, thus impacting the preparation of future teachers.

Given the importance for pre-service teachers to utilize the potential of simulation technology, this research has been seen as an essential study to be conducted. In revealing the pre-service teachers' current practices of simulation technology, it is expected that they will have filled a degree of innovative practices into their future teaching practices. Understanding factors that could affect pre-service teachers' decision to apply simulation technology into their teaching and learning is also vital in providing necessary interventions and support. Furthermore, the proposed model for the integration of simulation technology aims to provide guidance and serve as a reference for educators, public and private teachers' training institutions, and also government agencies in establishing a standard for successful integration of simulation technology.

2. Simulation Technology in Teacher Education

The integration of simulation technology in teacher education has gained attention due to its possibility of enhancing pedagogical skills, classroom management, and decision-making capabilities (Flavin & Levin, 2024). By utilizing simulation technology, pre-service teachers are now able to undergo training in a more structured, conductive, and effective setting (Nystrom & Ahn, 2024). The integration of simulation technology applications and approaches, such as Virtual Reality (VR), Augmented Reality (AR), and Mixed-Reality (MR) offers pre-service teachers immersive experiences that enable them to engage with a

simulated classroom environment (Wang & Li, 2024). Additionally, Mixed-Reality Simulations, which combine human-controlled avatars with artificial intelligence (AI) to replicate real-world classroom interactions with Digital Role-Playing Games, provide prospects for teachers to introduce instructional and classroom management strategies through a gamified environment (Wang & Li, 2024).

Previous studies have highlighted the advantages of integrating simulation technology in preparing for future teachers. Simulated classrooms create a risk-free environment where teachers can practice responding to various student behaviors (Nor & Zubir, 2023). Participation in virtual simulations enhances the readiness and confidence of pre-service teachers, making them more prepared for actual classroom settings (Levin, Herni & Kasperski, 2025). A study conducted by Levin (2024) indicated that simulations enable pre-service teachers to make instructional decisions and observe their immediate consequences in a safe, supportive, conducive, and practical context. Furthermore, simulation technology offers personalized and tailored training learning experiences to meet individual teachers' needs, reinforcing strengths and addressing weaknesses (Nystrom & Ahn, 2024).

Nevertheless, the implementation of simulation technology encounters several challenges. The requirement for substantial investment in high-quality virtual reality and AI-driven simulations restricts access and availability for educational institutions (Elendu et al., 2024). Additionally, technological challenges arise as some pre-service teachers may struggle with the learning curve associated with advanced and sophisticated simulation platforms. Issues related to the authenticity of experiences and ethical considerations also complicate the integration of simulation technology into pre-service teachers' education (Sturmer et al., 2024). Although simulations create controlled environments, they may not adequately reflect the unpredictability of real-world classroom settings. Moreover, the use of AI-driven avatars raises concerns regarding biases in programmed responses and the ethical implications of simulated student interactions (Pinheiro et al., 2025).

In light of these advantages and challenges, the study investigated the acceptance of simulation technology by pre-service teachers. The study also explores the factors that might influence their decision to integrate simulation technology into their future teaching practices. Given the limited similar published research and the increasing demand for technological teaching approaches, especially among future teachers, the findings from this study aim to enhance accessibility, improve authenticity, and effectively integrate simulation technology into teachers' teaching methodologies.

3. Research Model and Hypotheses

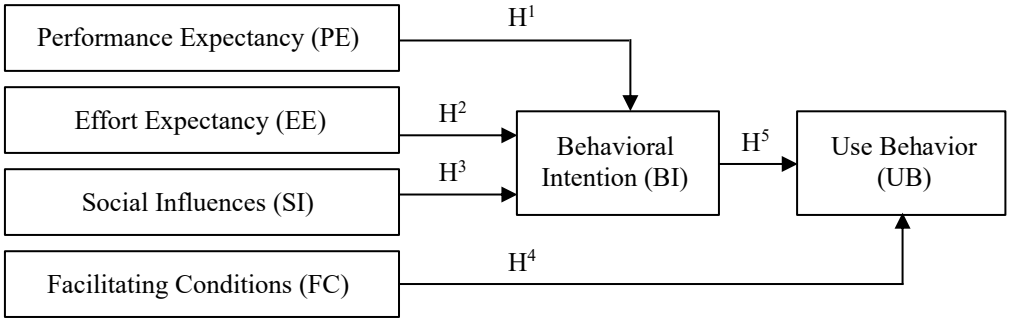
The Unified Theory of Acceptance and Use of Technology (UTAUT) was adapted as the foundation theory for this study. Recognized as one of the most widely used frameworks in technology adoption research, UTAUT elucidates the process by which users come to accept and use the proposed technology. UTAUT combines multiple theories and models, improves predictive accuracy, and considers social, organizational, and individual factors. The theory's versatility makes it an essential framework for studying technology acceptance in various settings.

The theoretical model of UTAUT suggests that the Use behavior (UB) of technology is determined by the users' Behavioral Intention (BI). As illustrated in Figure 1, UTAUT identifies four key constructs that directly influence user technology adoption, namely Performance Expectancy (PE), Effort Expectancy (EE), Social Influences (SI), and Facilitating Conditions (FC) (Venkatesh, 2022). PE is defined as users' belief that using the technology will improve job performance, whereas EE refers to users' perceived ease of use. On the other hand, SI indicates users' influence on others on adoption decisions, and FC is defined as the availability of resources and support. Although UTAUT has introduced four individual differences (gender, age, experience, and voluntariness of use) as moderating variables that are used to adjust the impact of the key constructs, the impact of those variables was not included in this study. In light of these statements, the present study proposed the following hypotheses:

H^1: The Malaysian pre-service teachers' Performance Expectancy (PE) positively influences their Behavioral Intention (BI) to use simulation technology
H^2: The Malaysian pre-service teachers' Effort Expectancy (EE) positively influences their Behavioral Intention (BI) to use simulation technology
H^3: The Malaysian pre-service teachers' Social Influences (SI) positively influence their Behavioral Intention (BI) to use simulation technology
H^4: The Malaysian pre-service teachers' Facilitating Conditions (FC) positively influence their Use behavior (UB) of simulation technology
H^5: The Malaysian pre-service teachers' Behavioral Intention (BI) to use simulation technology positively influences their Use Behavior (UB)

Figure 1

The research model



4. Research Methodology

This research has employed a quantitative type of research method to determine Malaysian pre-service teachers' acceptance of integrating simulation technology into their teaching and future educational practices. The study focuses on three groups of Science Education pre-service teachers from one of the public universities in Malaysia. A total of 256 pre-service teachers were selected through purposive sampling to ensure adequate representation across various Science disciplines, including Physics, Chemistry, and Biology, as well as different grade levels. The six stages of adoption self-determination question by Rusell (1996) were adapted to determine pre-service teachers' current usage of simulation technology. Those stages were regrouped into three main levels of indicator, which are high, moderate, and low levels of usage.

In addition, the Unified Theory of Acceptance and Use of Technology (UTAUT) questionnaire was adapted in this study. This self-administered questionnaire is divided into two sections. The first section gathers demographic information about the pre-service teachers, while the second section evaluates factors that influence their decision to use simulation technology. The second section includes five subsections with a total of 35 items. The data collected were analyzed using descriptive statistics and Structural Equation Modelling (SEM) using IBM Statistical Package for the Social Sciences (SPSS version 20.0) and SmartPLS software.

5. Research Findings

This section is presented in four different subsections. The initial sub-section focused on assessing demographic information, the second sub-section determined the current usage level of simulation technology, and the third sub-section evaluated the reliability and validity of items corresponding to each construct as outlined in the research model. The final subsection discusses the research hypotheses and the fit indexes of the research model.

5.1 Demographic Information

A total of 324 Science Education pre-service teachers were identified as the population for this study. These individuals are in their third and fourth year of study (grade level) across three distinct Science teacher education programs: Physics, Chemistry, and Biology. Of the total, 256 responded, resulting in a response rate of 79 percent. As indicated in Table 1, the majority (73%) of the respondents were female. On the other hand, the distribution of pre-service teachers across various Science education disciplines and grade levels was nearly equal. The largest proportion (35.5%) of respondents were from the Physics education program, and most (52.3%) of the respondents were in the third year of their academic program.

Table 1

Demographic information of the respondents (n = 256)

Variable	Category	Frequency (f)	Percentage (%)
Gander	Male	69	27.0
	Female	187	73.0
Discipline	Physics	91	35.5
	Chemistry	85	33.2
	Biology	80	31.3
Grade Level	Third year	134	52.3
	Fourth year	122	47.7

5.2 Current Usage of Simulation Technology

Pre-service teachers' self-assessments of current usage of simulation technology were determined by frequency and percentage of responses. As presented in Table 2, most (36.7%) of respondents claimed to be in stage 3, followed by stage 2 (26.6%), and the least is stage 1 (4.3%). A small number was recorded in stage 5 and stage 6, with a percentage of 8.2 percent and 5.9 percent, respectively. The finding shows that although a consistent increment was recorded from stage 1 to stage 3, a decreasing percentage was found at stage 4 and stage 5. Therefore, these results concluded that Malaysian pre-service teachers were at a moderate level of their current simulation technology usage.

Table 2

Demographic information of the respondents (n = 256)

Stages of Adoption	Level of Usage	Frequency (f)	Percentage (%)
Stage 1: Awareness	Low level of adoption	11	4.3
Stage 2: Learning the process		68	26.6
Stage 3: Understanding & application the process	Moderate level of adoption	94	36.7
Stage 4: Familiarity & confidence		47	18.3
Stage 5: Adaptation to other contexts	High level of adoption	21	8.2
Stage 6: Creative application to new contexts		15	5.9

5.3 Reliability and Validity of Constructs

The instrument's reliability was measured through the Cronbach's alpha coefficient. As shown in Table 3, Cronbach's alpha coefficient for each construct has reached an acceptable level of reliability (Kline, 2011), with an average value of 0.843. These Cronbach's alpha values indicate good internal consistency. This outcome can be explained by constructed items that were adapted from established questionnaires. Conversely, an Exploratory Factor Analysis (EFA) was performed to measure the construct validity. The results of the factor analysis, as shown in Appendix 1 indicated that all of the items have correlated of at least 0.5 with Kaiser-Meyer-Olkin (KMO) measure for each construct respectively, ranging from .579 - .886. This suggests that the construct validity is acceptable.

Table 3

Reliability of constructs

Construct	Number of Item	Cronbach's Alpha
Performance Expectancy (PE)	7	.852
Effort Expectancy (EE)	7	.821
Social Influences (SI)	7	.833
Facilitating Conditions (FC)	7	.843
Behavioral Intention (BI)	7	.832
Use Behavior (UB)	7	.875

5.4 Research Hypotheses Testing

Path coefficient analyses were conducted to assess the relationship of the designated path and verify the research hypothesis of the study. The findings in Figure 2 indicate that all the research hypotheses were significant. The highest significant impact was recorded on the relationship between FC toward UB with the Beta (B) value of 0.629 ($p<0.001$). Significant direct effects were also found on the relationship between PE toward BI ($B = 0.279$, $p<0.01$), EE toward BI ($B = 0.370$, $p<0.01$), SI toward BI ($B = 0.093$, $p<0.05$), and BI toward USE ($B = 0.361$, $p<0.01$). Conversely, the R2 value of USE indicates that 68.3 percent of its variance was predicted from Malaysian pre-service teachers' BI to use simulation technology.

5.5 The Model Fit Index

Five indicators, which are Standardized Root Mean Square Error of Approximation (RMSEA), Goodness of Fit (GFI), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Chi-Square to its degree of freedom (x2/df) were determined in assessing the model fit of the research model. As presented in Table 4, all model fit indicators meet the recommended thresholds. This confirmatory evidence indicates that the proposed structural model is a good fit.

Table 4

Model fit indices for the structural model

Fit Indexes	Values	Thresholds	References
RMSEA	0.058	RMSEA < 0.08	Hu & Bentler (1998)
GFI	0.905	GFI > 0.90	
CFI	0.974	CFI > 0.90	
TLI	0.955	TLI > 0.90	
Chi-Square (x2/df)	1.856	x2/df < 5.0	Marsh & Hocevar (1985)

6. Research Discussion

The present study suggested that the Malaysian pre-service teachers' current usage of simulation technology is at a moderate level. Most of them are at the stage of beginning to understand the process and thinking of specific applications of simulation technology in their teaching practices. Moreover, the pre-service teachers still lack the confidence to use it as most of them do not have experience and skills related to simulation technology. Similar to the finding suggested by Sing-Pillay (2024), the present study informs that although pre-service teachers are excited about the possibilities and potentials of simulation technology, they are still unsure about how the technology should be integrated into their teaching and learning process. They might integrate the simulation technology at the very basic function, which does not reflect the full potential, effective, and creative usage of the technology. Based on these findings, it is suggested that in order to build pre-service teachers' confidence and proficiency in integrating simulation technology, they need to have access to continuous related and relevant professional development courses. As suggested by Levin, Herni, and Kasperski (2025) users are more likely to posit a higher adoption level when it is convenient to use and practical for them.

In explaining the Malaysian pre-service teacher's decision to integrate simulation technology, the study has found that Performance Expectancy (PE), Effort Expectancy (EE), and Social Influences (SI) have positive significant direct impacts on their Behavioral Intention (BI). The finding also suggested that pre-service teachers' Effort Expectancy (EE) was found to be the main factor affecting their BI to integrate simulation technology. This result indicates that pre-service teachers' intention to use simulation technology will increase if the technology able to improve their teaching and learning performance. Conversely, the convenience of using the simulation technology and encouragement from others would also contribute to pre-service teachers' intention to use the technology.

Moreover, the study also has indicated that Facilitating Conditions (FC) as the most influencing predictor toward Malaysian pre-service teachers' usage (UB) of the technology. In line with previous studies (Anwar, Musa & Salleh, 2025) this finding implies that the pre-service teachers who agreed with the adequacy of related facilities provided to them are more likely to integrate it. Without sufficient quantity and quality of simulation technology equipment, it would decrease its usage. Based on this finding, it is suggested that in order to assist pre-service teachers in integrating simulation technology, facilities and resources are important factors in supporting their activities. Conversely, a significant direct effect on the relationship between the Malaysian pre-service teachers' Behavioral Intention (BI) to use simulation technology toward their Use behavior (UB) has suggested that pre-service teacher's intention to integrate simulation technology will influence their decision to use it.

7. Conclusion

Indeed, technological advancement nowadays has somehow created a global, dynamic, and interactive learning environment that improves the teaching and learning process. Likewise, with other technological tools and applications, the integration of simulation technology into classroom instruction is vital, due to its uniqueness, advantages, and potential to promote effective, creative, and innovative instruction. The present study suggested that the moderate level of simulation technology usage among Malaysian pre-service teachers was largely influenced by the level of support provided to them. The majority of them understand and currently applying the process, even though some of them might think about how they should apply that creatively and effectively into their teaching practice. This unpleasant situation might be due to the limited availability of simulation technology applications, that are able to encourage its integration into the teaching and learning process. Hence, teachers' involvement in continuous and relevant professional development courses seems important. Moreover, widespread technical training that includes comprehensive pedagogical content is necessary, especially among pre-service teachers since they are the change agents and deciders toward any proposed technology integration.

In determining factors that might influence Malaysian pre-service teachers' usage of simulation technology, the present study suggests that the more they perceive the technology to be useful and easy to use, the more they will tend to integrate it into their teaching practice. It is therefore suggested that the curriculum for the Malaysian pre-service teacher training programs should focus on the usefulness and ease of use of simulation technology in teaching and learning. The conduct of professional development courses that are tailored to meet pre-service teachers' specific needs and match their specific subject areas and pedagogical approaches are also suggested. Being a main factor in determining Malaysian pre-service teachers' usage of simulation technology, the study suggests that teachers need to be supported with appropriate infrastructure for them to integrate it into their teaching practice. This statement has called for the Malaysian government and school leaders to furnish teachers and schools with relevant technological equipment. It appears that when more support is given, teachers are more likely to integrate simulation technology into their teaching practice. Moreover, specific policies and guidelines for instructors of teachers training institutions, school leaders, and in-service teachers are needed to facilitate effective and creative integration of simulation technology. Thus, the model proposed in this study hopes to serve as a guideline and reference for schools, teachers training institutions, and the government in developing standards for the successful integration of simulation technology among pre-service teachers, especially in the Malaysian context.

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9. Co-author Contribution

The authors affirmed that there is no conflict of interest in this article.

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