Impact of the Use of Fuzzy Comprehensive Evaluation Applications towards Computational Thinking Skill Students in Engineering Education

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***Abstract*—Technology can enhance the accessibility of higher education, providing equal opportunities to students from diverse backgrounds. Technology plays a crucial role in higher education by revolutionizing the learning process and the utilization of educational resources by students. The application of Fuzzy Comprehensive Evaluation (FCE) in higher education significantly enhances computational thinking skills by improving instructional quality, expanding the scope and objectivity of student performance evaluations, and enhancing the assessment of learning outcomes. The study involved 919 participants who voluntarily provided data. The participants were selected using convenience sampling, which involves gathering data from individuals who are representative of the overall population and are willing to participate. The findings of this study suggest that self-efficacy has a substantial impact on computational thinking skills, perceived usefulness, perceived ease of use, and attitude towards using. Self-efficacy is the term used to describe an individual's belief in their ability to successfully handle various situations. The perceived usefulness of a system is strongly linked to this idea, which pertains to how much someone thinks it will help them do better is called attitude. This research shows that self-efficacy has a good effect on how useful something is seen to be.**

***Keywords*—fuzzy comprehensive evaluation, self-efficacy, technology acceptance model, computational thinking skill**

I. Introduction

Technology can enhance the accessibility of higher education, providing equal opportunities to students from diverse backgrounds [1–3]. However, significant disparities exist in the utilization of technology among students from various academic disciplines and socioeconomic backgrounds [4, 5]. Educational instruction and the application of educational resources to students are revolutionized by technology, which plays a crucial role in higher education [6, 7]. The TAM evaluates the level of adoption of technology in higher education [8, 9]. The Fuzzy Comprehensive Evaluation (FCE) method is used to rate simulated evaluations, this method is based on fuzzy mathematics [10, 11]. It turns quantitative ratings into qualitative ones by using the idea of membership degrees [12]. This way of looking at things is constructive when judging complicated situations with many parts, subjective opinions, and unclear information [13]. Fuzzy comprehensive evaluation is a strong way to look at complicated situations because it uses qualitative and numeric factors, makes the evaluation more objective and realistic, and handles uncertainty [14, 15]. It's useful in many areas because it has a structure that lets you evaluate success in every way [14].

FCE has the potential to significantly impact students' learning by providing them with a comprehensive and equitable assessment of their work [16]. FCE effectively handles student evaluations, despite their subjective nature and inherent uncertainties [17]. Administering assessments to students becomes significantly more accurate and dependable when the tests are capable of effectively addressing the numerous intricate challenges, they encounter [14, 18]. The combination of qualitative and quantitative elements in the FCE is crucial for evaluating students' advancement in various domains [19]. This combination enables the attainment of a more precise and equitable representation of students' learning outcomes [16, 20].

The FCE can assess the effectiveness of educational programs in enhancing the mental well-being and self-confidence of college students studying education and mental health [21]. The FCE method facilitates students' comprehension of the interplay between various approaches, which is crucial for unlocking their inherent capabilities [22]. The FCE is a valuable tool for those in the domains of education, psychology, and other related disciplines. It provides a robust framework for assessing self-efficacy by considering several aspects and human experiences [23].

The FCE comprehensively evaluates the capabilities of Computational Thinking (CT) by taking into account several factors, including the human experience [24]. This method evaluates the competency and mindset in CT skills that are essential for effective problem-solving and optimal performance in a digital work environment [25, 26]. The enhancement of cognitive abilities in training programs can be evaluated by employing the FCE. To improve in handling various challenges, one must comprehend the intricate connections between critical thinking abilities and attitudes [14, 27]. The FCE effectively assesses critical thinking skills by taking into account multiple factors and real-world experiences [15]. It offers impartial and comprehensive evaluation, rendering it beneficial in both academic and business contexts. Finally, from the explanations above, this study aims to answer several questions including, how does the use of fuzzy comprehensive evaluation applications affect self-efficacy among engineering students? How could self-efficacy influence the technology acceptance of engineering students that impacts to their computational thinking skills? Which then from the above questions will be compiled to become a model that aims to be able to increase knowledge for teachers to be able to improve the quality of teaching.

II. Literature Review

A. Self-Efficacy

Self-efficacy is frequently considered a powerful predictor of individual behavior. Bandura (1986) [28] is the individual responsible for its development. Self-efficacy is described in this context as a person's "confidence in her/his ability to accomplish a goal or outcome" [29]. People who have faith in their abilities are more inclined to work diligently to accomplish their objectives and to feel confident in their abilities [28]. Self-efficacy may be a domain-specific notion, according to [30], who proposed that self-efficacy conceptions were possibly influenced by the control perception of the facilitators/inhibitors and the strength appraisal of a target behavior. Self-efficacy is a person's confidence in their ability to succeed [31]. A high level of self-efficacy is required for students to effectively employ technology-based learning aids [32]. Self-efficacy positively influences the uptake of technology and the perceived benefits, which in turn results in increased motivation and satisfaction with learning. Utilization of technology and behavior are both influenced by self-efficacy [33]. Highly self-confident people are more inclined to employ technology that is both user-friendly and advantageous, as they are confident in their ability to achieve their goals. Attitudes, behavior, and learning are all influenced by self-efficacy.

B. Perceived Usefulness

Davis's paradigm of acceptance of technology [34] posits that individuals' perceptions and attitudes towards using influence their perception of its usefulness. In their study, Weng *et al*. [35] demonstrated the influence of students' cognitive perception of learning on their use of contemporary technology. During the course of their studies, the students employed the applications on their devices as educational technologies [36]. The significance of user value becomes apparent when resources are easily accessible [37]. Additionally, we investigate how learners use of technological tools affects their grades. Our objective is to ascertain the degree of alignment between the learning styles and teaching methods of students and to evaluate the effect of this alignment on their academic performance.

C. Perceived Ease of Use

Davis (2004) [34], says the level to which people think that using a certain method will make things better is called its apparent ease of use. Perceptions of how useful and easy-to-use technology is seen by people are often used to predict how widely it will be used. But based on the situation, the exact ideas can be different for each technology and its users [36]. According to Cheon *et al*. [38], how long people use educational apps depend on their usefulness and usability. As per Lai *et al*. [39], technology used in the classroom and students' expectations of its benefits is important. Park *et al*. [40], shows that students' perception of the usefulness of something significantly influences their perception of the value of mobile education. According to Davis [34], the widespread accessibility and user-friendliness of new technologies have made their use in education an integral aspect of daily life. Various types of educational technologies have proliferated across all academic disciplines [41]. The perception of students regarding the usefull and the level of user-friendliness of the learning materials they utilize directly impacts their learning process [42]. Consequently, these beliefs influence their inclination to continue acquiring knowledge through digital tools or other platforms that employ tools [40].

D. Attitude toward Using

Evaluating educational technology ensures that students maintain a high level of learning [33, 40]. Research has revealed that engineering graduates must rapidly acquire proficiency in utilizing novel technologies in order to secure employment in the digital era [4, 43, 44]. Possessing the appropriate technological skills is crucial for delivering a high-quality education [45]. Emerging educational technologies have the ability to help students discover more and understand what they're reading, facilitate the learning process, and ultimately foster overall academic achievement [9, 45]. This instruction is rendered ineffective if the students fail to adhere to it [6]. The scope of our comprehension regarding user-friendly media is constantly expanding, the ability to assist the student in comprehending the significance of the subjects they are studying [19, 35]. Because of this, it is very important to look into what makes students want to do online learning [33, 44]. In recent times, an increasing number of students are bringing their mobile phones to school [1, 2]. The fast pace of progress in technology has made it feasible to acquire knowledge remotely. Students have the option to utilize mobile applications that provide fundamental lessons and additional educational resources. Research has demonstrated that the extensive utilization of cell phones by students [46] benefits individuals involved in the development of mobile applications. This feature facilitates remote participation in lessons for students, regardless of their location. The impact of phone apps on students' grades and happiness is contingent upon the specific app, its usage context, and the student's background.

E. Computational Thinking Skill

Computational Thinking (CT) skills employ computer concepts to facilitate problem-solving, critical thinking, and creativity in individuals [24, 25]. Being able to think like a machine and solve difficult issues is a crucial ability in the 21st century. Computational thinking encompasses a broader spectrum of problem-solving methodologies that may be applied across various domains and circumstances, extending beyond coding or programming [47]. Schools frequently incorporate these subjects into their curriculum to prepare students for future employment opportunities and advancements in technology [48]. The user's conviction that utilizing computational tools will facilitate problem-solving and enhance computational thinking might be regarded as perceived value [8, 38]. This can impact their readiness to utilize and embrace CT tools and platforms. Perceived ease of use can be conceptualized as the user's subjective assessment that CT tools are straightforward and user-friendly [44, 49]. Individuals are more inclined to utilize technology that they find comprehensible, their perception of CT tools can influence their motivation to employ them [25, 37]. An individual's behavioral objective is to utilize CT tools and platforms to enhance their proficiency in computational thinking [40, 50]. This objective could be a reason to do something individuals to utilize and embrace CT tools, hence enhancing their proficiency in CT.

The evaluation process in FCE commences with problem definition, followed by the decomposition into smaller, more manageable components [51]. This aligns with the decomposition and abstraction phases of computational thinking, wherein problems are segmented into smaller, more manageable components [52]. In FCE, the solution is rendered more general, and the plan is assessed during its formulation. This resembles the generalization phase in computational thinking, during which solutions and plans are formulated [53]. Utilizing FCE to assess intricate, multifaceted issues is particularly beneficial, constituting a crucial aspect of computational thinking. It amalgamates scores from multiple distinct variables into a singular score for the dependent variable [54]. Therefore, The theories above serve as a foundation for us to conduct this study. Fig. 1 displays the hypothesized pathways tested in this study.

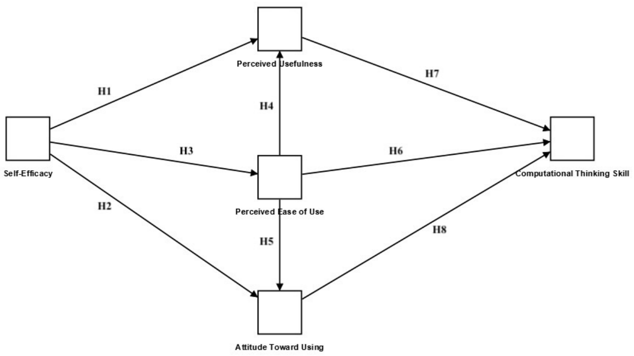

Fig. 1. Hypothesis development.

III. Materials and Methods

A. Design of the Study

Quantitative methods used in this study, that are facilitate a comprehensive examination of the interconnections among all the elements under inquiry [55]. The purposive sampling strategy was utilized to effectively capture the research objectives and acquire precise information from students. 919 college students in Indonesia were analyzed for this study. The survey was conducted using a pre-established online platform, and participants were recruited using various internet channels for this study. The participants previously used the Fuzzy exhaustive evaluation software, which is an instructional application specifically designed for the Android platform. Some images and explanations of the application are described in the following sections.

In Fig. 2, there is a dashboard view of the application, and will be taken to the login page to fill in the email and password, and if there is no login access, you can register first.

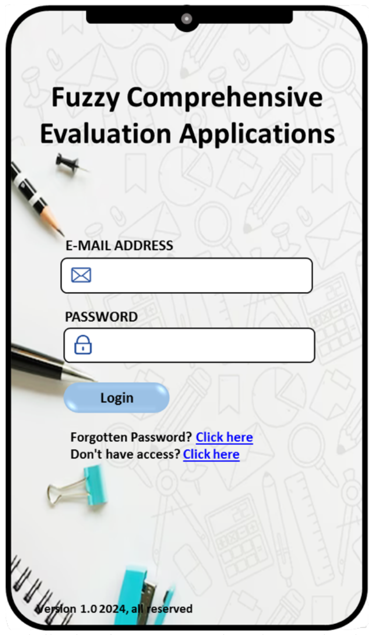

Fig. 2. Dashboard display fuzzy comprehensive evaluation applications.

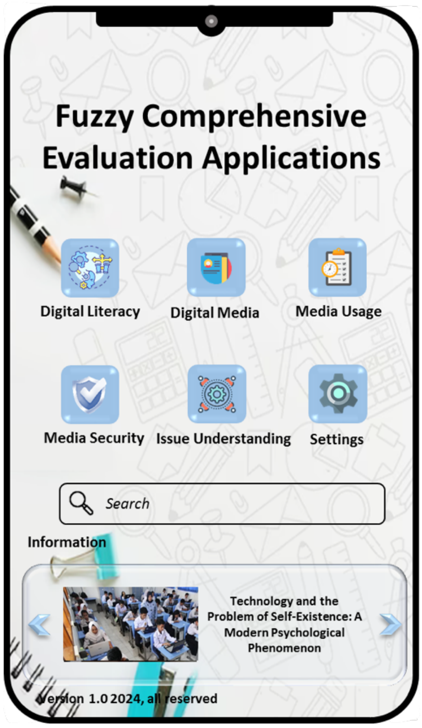

Fig. 3. Display of Fuzzy comprehensive evaluation application menus.

In Fig. 3, several options are shown in the application. Where there are several options that can be selected according to the needs or desires of its users. In this section, there are fuzzy comprehensive evaluation application menus consisting of curriculum, content standards, process standards, competency standards, profiles, setting and has information that may useful for the users.

B. Sample

A total of 919 individuals were entrusted with the instrument, and without exception, each person returned it to the original owner. The evaluation involved a grand total of 919 participants. The research effort employed a method called convenience sampling. Convenience sampling was implemented in this investigation due to the practical constraints and the nature of the investigation. The convenience sampling method was a simple and efficient method of collecting data from a large group of individuals who were at ease with being surveyed, as 5,721 eligible students from Universitas Negeri Padang had already used the app. This approach enabled the research team to acquire critical knowledge in a brief period and with restricted resources by concentrating on students who had directly utilized the application, thereby ensuring that it was pertinent to the study's objectives. The study ensures that the data collected is directly related to the primary research question, which is the perceptions of the app's effects among students who have previously used it, by selecting individuals who have previously used the app. This method is more dependable because it ensures that the sample is composed of individuals who have direct experience with the application in question. This approach entails gathering data from individuals who are representative of the overall population and willingly offered it. If the respondent is willing to offer the information, this method allows any individual who is willing to voluntarily provide the researcher with the appropriate instrument to take part in the research by way of sampling. In order to uphold ethical standards, we ensured that the data provided by the respondents was protected. This was achieved by ensuring that the respondents were informed in each questionnaire that the data would be kept confidential and used exclusively for the purposes of this study. Table 1 provides a detailed analysis of the individual attributes of the participants. Consequently, the relationship between the data from the sample and the characteristics of the full population is weakened as a result of this.

Table 1. Participants demography

Gender	Number	Percentage
Male	543	59,09%
Female	376	40,91%
Total	919	100,00%
	Age (Year)	
17–18	26	2,83%
19–20	404	43,96%
21–22	370	40,26%
23–24	81	8,81%
24 above	38	4,13%
Total	919	100,00%

C. Instrument

Surveys were employed as research instruments in the context of this investigation. Most of the test tools that were used in this study came from earlier investigations. Filling out the form is an important part of research because it helps researchers figure out what factors are important for the study. This questionnaire's goal is to get accurate data on a number of areas, such as self-efficacy, perceived usefulness, perceived ease of use, attitude toward using, and computational thinking skills. A questionnaire using the Likert Scale was used to rate and analyze the test items in this study. The questionnaire consists of twenty-one questions designed to assess five distinct elements. The Smart-PLS application assesses the factor loading value of each question to determine its level of accuracy. For validation for convergent validity, we used SmartPLS's standard item loadings to figure out the average variance extraction (AVE). To ensure the parameters and predictions were legitimate, we utilized the heterotrait-monotrait correlation ratio (HTMT). Ensure that the study's components were internally consistent, researchers utilized Cronbach's alpha and CR. Each variable has its own set of associated questions, and this list has them all. The PLS-SEM method employs the IPMA, or Partial Least Squares Structural Equation Analysis to look at how different parts of a model are connected to each other. The updated route coefficients now incorporate an additional feature that takes into account the mean scores of the hidden variable. This shows how the previous structure affects the objective's structure. Put simply, it assesses the extent to which the predictor influences the outcome.

The instrument used to measure the self-efficacy adopted from the study has been done by Zhao *et al*. (2021) [56] five items adopted, such as "I feel certain that I can understand this fuzzy comprehensive evaluation application" and "I believe that I can understand the concepts of this fuzzy comprehensive evaluation application". The instrument used to measure the perceived usefulness adopted from the study has been done by Li *et al*. (2024) [57] three items adopted, such as "Using fuzzy comprehensive evaluation application in building independent curriculum strategy in Higher Education". The instrument used to measure the perceived ease of use adopted from the study has been done by Na *et al*. (2023) [58] three items adopted, such as "Very easy to use fuzzy comprehensive evaluation app". The instrument used to measure the attitude toward using adopted from the study has been done by Al-Rahmi *et al*. (2021) [59] five items adopted, such as "Using the fuzzy comprehensive evaluation app in class is good" and "Using the fuzzy comprehensive evaluation app in class is favorable". The instrument used to measure computational thinking skill adopted from the study has been done by Cheng *et al*. (2021) [53] five items adopted, such as "If a problem occurs while using the fuzzy comprehensive evaluation application, you can find steps to find the right solution" and "You can discard unimportant information while using the fuzzy comprehensive evaluation application".

D. Data Validation

To study the tool using SEM-PLS, we used SmartPLS version 4 software. Some problems that can happen with Ordinary Least Square (OLS) regression analysis are not having enough data, missing values, an odd distribution of data, and signs of multicollinearity. In order to solve these issues, PLS was created. SmartPLS was used to make sure that The measurements and models of the structure were accurate. Anderson and Gerbing (1988) [60] This research's data was analyzed in two steps. Initially, it was imperative to ensure the study concept and the methodology for data collection were robust and precise. In order to check the test's validity, AVE (Average Variance Extracted) and normal item loading were used. An evaluation of the test's discriminatory power was conducted using the heterotrait-monotrait correlation ratio (HTMT). To ensure that the study models were internally consistent, Cronbach's alpha and composite reliability (CR) were employed. The next step was to determine if a structural relationship existed by using the bootstrap test that was statistically significant between the study's parts. Table 2 shows how the instruments were loaded for the study. As needed by Hair *et al*. (2012) [61], Convergent validity is demonstrated in Table 2 by All marker factor loadings on the latent concept are more than 0.60.

Table 2. Instrument and loadings

Item	Outer loadings
ATU1. "Using the fuzzy comprehensive evaluation app in class is good."	0.835
ATU2. "Using the fuzzy comprehensive evaluation app in class is favorable."	0.890
ATU3. "It is a positive influence for me to use the fuzzy comprehensive evaluation app in class."	0.895
ATU4. "I think it is valuable to use the fuzzy comprehensive evaluation app in class."	0.871
ATU5. "I think it is a trend to use the fuzzy comprehensive evaluation app in class."	0.843
CTS1. "You can operate the fuzzy comprehensive evaluation application from start to finish correctly."	0.819
CTS2. "If a problem occurs while using the fuzzy comprehensive evaluation application, you can find the steps to find the right solution."	0.786
CTS3. "You can discard unimportant information when using the fuzzy comprehensive evaluation application."	0.817
CTS4. "You can solve the same problem with the same steps when using the fuzzy comprehensive evaluation application with different features."	0.805
CTS5. "You can make conclusions and understand the purpose of the application quickly when using the fuzzy comprehensive evaluation application."	0.816
PEU1. "It is easy to use the fuzzy comprehensive evaluation application."	0.855
PEU2. "I find it easy to apply the fuzzy comprehensive evaluation application for my learning evaluation."	0.792
PEU3. "Using a fuzzy comprehensive evaluation application is easy and understandable."	0.744
PU1. "Using fuzzy comprehensive evaluation applications in building independent curriculum strategies in Higher Education."	0.798
PU2. "Using fuzzy comprehensive evaluation application improves the feedback of learning content standards in Higher Education."	0.735
PU3. "Using a fuzzy comprehensive evaluation application makes it easier to understand the individual needs of students"	0.823
SE1. "I feel certain that I can understand this fuzzy comprehensive evaluation application."	0.842
SE2. "I believe that I can understand the concepts of this fuzzy comprehensive evaluation application."	0.880
SE3. "I hope to do my best on this fuzzy comprehensive evaluation application."	0.872
SE4. "I feel certain that I can master the skills described in this fuzzy comprehensive evaluation application."	0.845
SE5. "Considering the difficulty and skills, I think that I can do well in this fuzzy comprehensive evaluation application."	0.822

The preceding table illustrates the outer loadings. The dependability of each indicator evaluated in this study is demonstrated by the subsequent figures. Reliability refers to the extent to which survey items consistently assess the intended constructs. The survey reliably yields consistent results under the same conditions and with identical participants by employing a rigorous measurement model. To draw valid conclusions about the surveyed individuals that can be consistently applied, maintaining this consistency is essential. The proper construction of a survey is ensured by a reliability test in higher education. Low reliability indicates that particular survey items fail to consistently assess the same construct. This indicates that the survey requires revision or the removal of ineffective items. In higher education, the rigor of research is paramount, especially when surveying extensive populations. Findings inform stakeholders, including administrators and policymakers.

In order to determine the PLS bootstrapping components, this study utilized a popular approach in structural equation modeling (SEM). Data collection for this approach included a variety of techniques that made advantage of repeated sampling. Standardized item loadings, composite reliability, Cronbach's alpha, and average variance extracted (AVE) might be used to evaluate the validity and reliability of the measures for each group. By following Hair *et al*. (2012) [61], Table 3 show that all of the combined reliability and Cronbach's alpha values are at least 0.70. It is evident that the factor loadings on each latent construct are AVE with minimum values 0.50 and construct-specific AVE values greater than 0.60 demonstrate this clearly.

Table 3. Cronbach's alpha, composite reliability, average variance extracted

Variable	CA	CR	AVE
Attitude Toward Using	0.917	0.918	0.752
Computational Thinking Skill	0.839	0.838	0.609
Perceived Ease of Use	0.715	0.729	0.637
Perceived Usefulness	0.555	0.596	0.523
Self-Efficacy	0.906	0.911	0.726

The average value of each design is more than.50. According to Hair *et al*. [61], While 0.50 is the lowest number that's accepted, all of the scores in Table 3 were between 0.523 and 0.752 Cronbach's alpha ranges from 0.596 to 0.918, and the composite reliability scale falls somewhere in the middle. Not only that, Table 4 displays the HTMT, or Heterotrait-Monotrait Ratio of Correlations. Hair *et al*. (2012) [61] assert that an HTMT correlation ratio below 0.90 satisfies the discriminant validity. The table shows that SE and ATU have the highest HTMT number at .875.

Table 4. Heterotrait-Monotrait Ratio of Correlations (HTMT)

Variable	ATU	CTS	PEU	PU	SE
ATU					
CTS	0.634				
PEU	0.433	0.602			
PU	0.444	0.645	0.841		
SE	0.875	0.688	0.399	0.412	

Validity testing verifies that SmartPLS' measurement model accurately represents the relationships between constructs and indicators. This enhances the precision and applicability of the results. Data from a highly valid survey instrument precisely represent college students' experiences, attitudes, and behaviors. Validity assessments are conducted to confirm that the survey questions effectively gauge the intended results. In the absence of validity testing, the likelihood of measuring irrelevant or unrelated factors increases, which may result in erroneous conclusions regarding the surveyed population.

Validity testing ascertains that survey items accurately assess the intended constructs, whereas reliability testing confirms that they consistently measure the same latent variables. By implementing these measures, researchers can guarantee that the survey data obtained from college students is precise and dependable. This enhances and bolsters the credibility of the study's results. Research in higher education necessitates dependable and valid outcomes to draw accurate conclusions and facilitate data-informed decisions.

E. Data Collection

According to Burns and Grove (2003) [62], while documenting research, it is crucial to incorporate the research setting, research participants, study range, and methods for data collecting and analysis. Additionally, it is imperative to include the research sample. All of the present engineering faculty students who received the questionnaire completed and returned it. As a requirement for participation, people were given an online form and a link to the poll to finish. If respondents fill out the surveys correctly, they are guaranteed to be able to move on to the tabulation step.

F. Data Analysis

The research was conducted using SmartPLS version 4. OLS regression analysis can encounter issues such as small data sets, incorrect data distribution, missing values, and multicollinearity. One efficient way to deal with these problems is to use the Partial Least Squares (PLS) analytical method. In order to guarantee the validity of the investigation, a measuring model was first used, following the steps laid out by Anderson and Gerbing (1988) [60]. In the second step, we made 5,000 bootstrapping examples to check how reliable the links between fields were. We employed the SmartPLS software to conduct the bootstrapping analysis during our hypothesis testing. In addition, we assessed the effectiveness of each construct by employing importance-performance map analysis (IPMA), thereby enhancing the utility of the PLS-SEM findings. Managers can make decisions about prioritizing actions by analyzing two variables: importance and performance. Therefore, it is advisable to focus on enhancing the efficiency of underperforming elements that play a crucial role in elucidating a specific desired outcome.

IV. RESULT AND DISCUSSION

SmartPLS analysis results are in Table 5 and Fig. 4. Using PLS analysis results, these demonstrate the pathways of all study assumptions. Hypothesis 1, self-efficacy and perceived usefulness has a positive and significant effect with $\beta = 0.103$ and $\rho = 0.001$. This suggests that high-self-efficacy people think technology is easier to use, which may enhance their intention to utilize it. Hypothesis 2, investigating the influence of self-efficacy and attitude toward using, were the result shows that positive and significant effect ($\beta = 0.802$, $\rho = 0.000$), students with stronger self-efficacy are more likely to have positive attitudes about technology, which can improve their educational experiences and outcomes. Hypothesis 3, self-efficacy has a positive and significant impact on perceived ease of use ($\beta = 0.325$, $\rho = 0.000$), developing self-efficacy improves students' attitudes and behavior regarding using technology for learning. Furthermore, hypothesis 4, perceived ease of use has a positive and significant impact on perceived usefulness ($\beta = 0.585$, ρ=0.000), demonstrating that individuals are more likely to find a technology beneficial if they think it's easy to use. Furthermore, hypothesis 5, perceived ease of use has a positive and significant impact on attitude toward using ($\beta = 0.087$, $\rho = 0.016$), user-friendly and simply understandable technology will be more appealing to youngsters and more likely to be used for education.

Moreover, hypothesis 6, perceived ease of use has a positive and significant impact on computational thinking skill ($\beta = 0.197$, $\rho = 0.000$), when technology seems simple, people are more likely to value it. When a technology seems easy to use, users are more likely to accept it. Moreover, hypothesis 7, perceived usefulness has a positive and significant impact on computational thinking skill ($\beta = 0.197$, $\rho = 0.000$), fostering the perception that technology is useful might improve pupils' computational thinking. Thus, learning outcomes, computational thinking, and technology use can improve. Students can improve their computational thinking skills with practice. Moreover, hypothesis 8, attitude toward using has a positive and significant impact on computational thinking skill ($\beta = 0.197$, $\rho = 0.000$), Research shows that technological attitudes improve computational thinking. This suggests that positive attitudes toward using use boost computational reasoning. A positive view of technology use can increase students' computational thinking skills, leading to improved learning results and higher proficiency.

Perceived usefulness is strongly and positively correlated with self-efficacy. This indicates that students with greater confidence in their technological skills are more likely to view it as advantageous. This underscores the importance of equipping students with training and support to enhance their confidence in their capabilities, thus allowing them to recognize the practical applications of technology in their academic endeavors. Educational institutions and educators ought to contemplate the implementation of programs that enhance self-efficacy to promote increased technology utilization among individuals. The level of self-efficacy significantly influences students' attitudes towards technology utilization. This indicates that students are considerably more predisposed to embrace and utilize technology when they possess greater confidence in their proficiency with digital tools. This indicates that schools ought to adopt interventions that bolster self-efficacy to improve students' perceptions of technology, consequently enhancing their overall learning experience and outcomes. Given the substantial impact of self-efficacy on perceived ease of use, students who possess confidence in their technological skills are inclined to find operations effortless. Educational institutions and policymakers must prioritize initiatives that enhance students' technical skills, thus enabling their effective incorporation of technology in the classroom. This may lead to a heightened rate of engagement and adoption.

Students are more likely to view technology as advantageous when they can use it with ease, as there is a relationship between usability and perceived value. This indicates that it is essential to develop user-friendly technology interfaces for students to foster their perception of these tools as advantageous for learning. This will consequently lead to increased acceptance and utilization of digital technologies in educational institutions. Enhancing technology's user-friendliness for students can positively influence their attitudes, as perceived ease of use correlates with a favorable disposition towards its utilization. Developers and educators must ensure that educational technologies are intuitive and accessible, especially for younger students, to enhance their engagement in utilizing these tools for learning. Considering that computational thinking skills are greatly affected by perceived ease of use, it is logical to conclude that students are more likely to engage with technology and improve their computational thinking capabilities when they perceive it as user-friendly. This indicates that educational technologies must be designed to be intuitive and uncomplicated to improve students' critical thinking skills, essential for future learning and problem-solving.

Students are more likely to utilize technology to improve their problem-solving skills when they recognize its relevance to computational thinking abilities. This suggests that instructing students to perceive technology as a valuable educational resource can profoundly impact their comprehension of computation and their overall learning experience. Educators and educational institutions must prioritize the practical applications of technology to enhance student learning. It is plausible to infer that students with a more favorable disposition towards technology are more inclined to improve their computational thinking skills, as their perceptions of technology substantially influence these abilities. Therefore, educational institutions need to create a supportive technological environment that encourages students to utilize digital tools. This will directly aid in enhancing their critical thinking and problem-solving abilities. The results illustrate the essential importance of self-efficacy, usability, and a constructive mindset in the improvement of educational technologies, especially regarding computational thinking instruction. Educational institutions and policymakers must cooperate to enhance these essential elements to elevate student outcomes and optimize technology utilization.

The concept of self-efficacy, as defined by Bandura (1986) [28], this is what the idea that self-efficacy has a big effect on how useful something is comes from. Self-efficacy is how confident a person is in their own ability to handle future scenarios by taking the right steps. This idea is connected to the idea of perceived usefulness, which is how much someone thinks a method will help them do their job better or do better in a certain situation. Several research papers on education have found that self-efficacy has a big good effect on how useful something is seen to be. Recently conducted study has shown that believing in one's own skills can have a big effect on how useful something is seen to be. According to Pradana *et al*. (2024) [32], there is evidence to support the idea that people with a stronger belief in their abilities are more inclined to view technology as valuable. Encouraging a strong sense of confidence in educational environments can lead to a more favourable outlook on using technology, ultimately boosting academic performance and sharpening computational thinking abilities. Having a strong belief in one's abilities has a notable influence on how individuals perceive the usefulness of technology. Those with higher self-efficacy tend to see technology as having a more positive and beneficial impact on their lives. There is proof from both real-world studies and theory models, such as the Technology Acceptance Model, that support the existence of this relationship [33, 44, 57].

Table 5. Hypothesis result

Hypothesis	β	ρ	Result
H1. Self-Efficacy -> Perceived Usefulness	0,103	0,001	Supported
H2. Self-Efficacy -> Attitude Toward Using	0,802	0,000	Supported
H3. Self-Efficacy -> Perceived Ease of Use	0,325	0,000	Supported
H4. Perceived Ease of Use -> Perceived Usefulness	0,585	0,000	Supported
H5. Perceived Ease of Use -> Attitude Toward Using	0,087	0,016	Supported
H6. Perceived Ease of Use -> Computational Thinking Skill	0,197	0,000	Supported
H7. Perceived Usefulness -> Computational Thinking Skill	0,177	0,000	Supported
H8. Attitude Toward Using -> Computational Thinking Skill	0,456	0,000	Supported

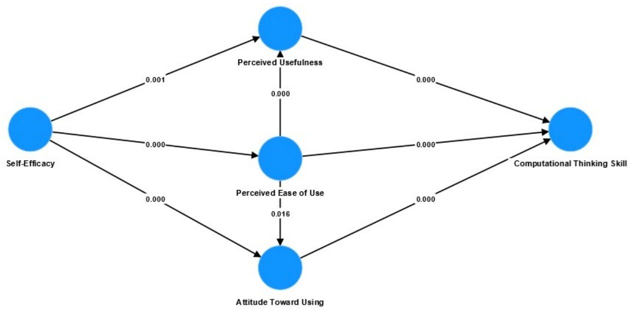

Fig. 4. Hypothesis path.

PLS-SEM analysis and an Importance-Performance Map Analysis (IPMA) to see how self-efficacy, perceived value, perceived ease of use, and attitude toward using affected the computational thinking skills. IPMA allows for the identification of crucial variables that are underperforming and need improvement. Table 6 and Fig. 5 below display the standardized total effects, which indicate importance, and the standardized latent variable scores, which indicate performance.

Table 6. Importance-Performance Map Analysis (IPMA)

Variable	Computational Thinking Skill	Performance
Attitude Toward Using	0,456	68,974
ATU1	0,100	72,470
ATU2	0,104	68,906
ATU3	0,102	67,193
ATU4	0,108	71,436
ATU5	0,111	64,581
Perceived Ease of Use	0,340	79,498
PEU1	0,159	81,665
PEU2	0,139	76,415
PEU3	0,125	80,005
Perceived Usefulness	0,177	78,299
PU1	0,071	74,538
PU2	0,063	69,505
PU3	0,106	84,820
Self-Efficacy	0,494	70,305
SE1	0,132	70,348
SE2	0,121	72,688
SE3	0,111	68,390
SE4	0,115	74,864
SE5	0,101	63,792

Regarding IPMA, Table 6 shows the details of IPMA on computational thinking skill, the biggest predictor for computational thinking skills is in the self-efficacy variable with a score of .494, with the highest instrument in SE1 with a score of 0.132 and SE2 with 0.121. And attitude toward using as the second predictor with a score of 0.456, with the instrument with the highest score being ATU5 with 0.111. Meanwhile, perceived ease of use, with the third largest effect for computational thinking skills with a score of 0.340 with the instrument with the largest effect is PEU1 with a score of 0.159. Finally, perceived usefulness provides the weakest influence, with a score of 0.177 and the smallest instrument is 0.071. While in terms of performance, the highest value is perceived ease of use with a score of 79.498. Perceived usefulness has a performance value of 78.299, followed by self-efficacy with a score of 70.305, lastly the performance score on attitude towards using is 68.974.

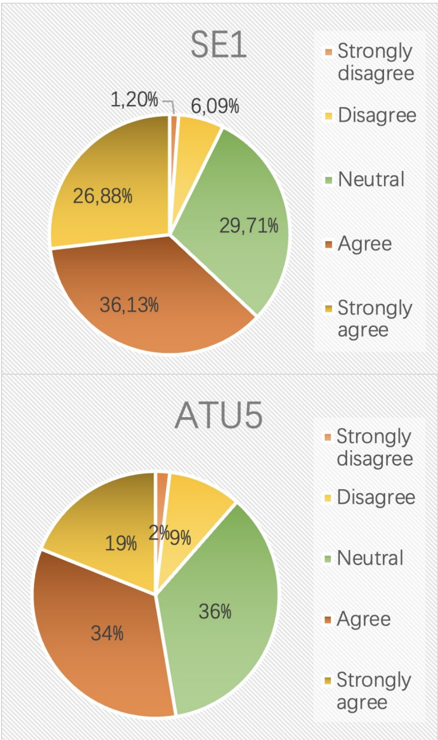

Fig. 5. Responses in SE1 and ATU 5.

Fig. 5 illustrates the responses given by respondents where SE has the most influence of IPMA in this study, with question item number 1 contributing the most with 0.132, where this question item is illustrated in percentage. In more detail, in this statement item, 26.88% of respondents stated that they strongly agree with this item, then 36.13% stated that they agree, where more than half of the respondents expressed their agreement with this statement, where they can understand and understand how to use the FCE application.

Furthermore, ATU as a direct predictor that has a major influence on computational thinking skills in students, where of the 5 statement items to represent ATU, the fifth item has a major contribution to this construct. Where more than half of the respondents gave an agreed response to this statement in detail, 34% of responses agreed, and 19% strongly agreed. This needs to be a concern for teachers to be one of the important aspects of improving computational thinking skills in the classroom or in the study groups they guide.

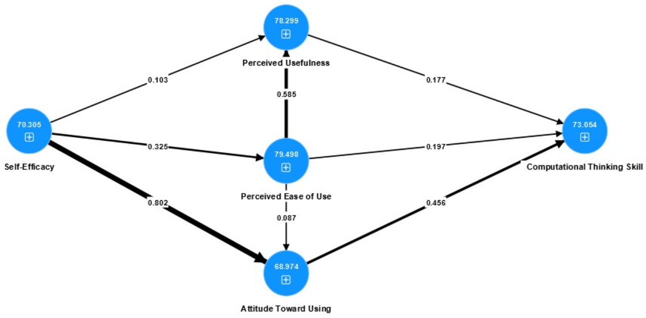

Fig. 6. IPMA path.

Fig. 6 shows the detailed path of the IPMA results, where self-efficacy has the greatest influence on attitude toward using with a value of 0.802, which is the largest. After that, attitude toward using has a large influence on computational thinking skills with 0.456. where this detail has a good impact. With a number of 0.325, self-efficacy also has a big effect on how easy something is to use. This is the third highest score. With a number of 0.103, self-efficacy doesn't have much of an impact on how useful something is, which may be a problem for teachers or people in charge of making decisions.

The substantial influence of self-efficacy on individuals' perceptions of digital tools highlights the importance of confidence in encouraging students to employ them. This illustrates the importance of integrating support systems that bolster self-efficacy, including intuitive interfaces and training initiatives. Moreover, an individual's attitude towards the application of computational thinking skills suggests that a more positive outlook on technology utilization can enhance problem-solving efficacy. Consequently, educators and policymakers must prioritize strategies that enhance students' confidence in employing digital tools, as this can promote the development of essential skills.

In contrast, perceived usefulness is less affected by self-efficacy, which could present a challenge for educators. Students' engagement and learning may be adversely affected if they do not regard educational technologies as advantageous, irrespective of their comfort with such tools. Consequently, it is essential to illustrate the practical applications of these tools to ensure that users recognize their usefull in the intended contexts. This information is essential for those tasked with identifying the most effective methods for leveraging technology to meet educational goals and user needs.

The IPMA results indicate that the success of the acquisition of computational thinking skills is significantly influenced by both self-efficacy and attitudes toward using of technology. Trust in technology and a positive perception of its usefull are the primary factors. Interventions that aim to enhance computational thinking should emphasize the development of self-efficacy through training, user-friendly interfaces, and practical applications of digital tools, as well as the promotion of positive attitudes toward using. Strategies may be required to emphasize the practical advantages of these tools in order to facilitate students' comprehension of their potential applications in problem-solving and learning.

This is due to the fact that perceived usefulness may not have as significant an impact.

V. Conclusion

This study illustrates that students' self-efficacy, perceived ease of use, perceived usefulness, and attitude toward using significantly influence their computational thinking abilities and the extent to which they utilize educational technology. Individuals' attitudes towards using, their perceived ease of use, and their perceived usefulness are significantly influenced by their self-efficacy. This suggests that more self-assured students are more likely to optimize the potential of technology in the classroom also, that the perceived ease of use of a product has an impact on the computational thinking skills, perceived usefulness, and attitudes toward using of students. This illustrates the importance of educational tools that are user-friendly and encourage critical thinking and problem-solving among students.

Additionally, the necessity of cultivating a positive attitude towards using in educational institutions is underscored by the substantial correlation between computational thinking skills and a positive perspective on technology. Institutions should prioritize the development of technologies that are both user-friendly and enjoyable to facilitate the acquisition of critical skills and academic success among students. To promote critical thinking, enhance engagement, and achieve academic success in an increasingly digital world, it is essential to cultivate students' self-efficacy and ensure that they perceive technology as both practical and user-friendly.

By cultivating high levels of self-efficacy, it is possible to enhance learning outcomes and increase the adoption of technology. This is achieved by bolstering users' confidence in the technology's ability to enhance performance. Individuals are significantly more likely to hold a tool in high regard if they perceive it as user-friendly. The cognitive load and workload of technology are reduced, which makes it easier to operate. Additionally, it becomes more appealing and accessible. When technological advancements are perceived as user-friendly, individuals are more likely to believe that they are advantageous. This is because individuals have a higher level of confidence in the ability of technology to help them achieve their goals or perform their responsibilities more efficiently. The ease of use of a tool has a substantial impact on its usefulness. Electronics that are effortless to operate are preferred by individuals. Individuals' utilization of tools is contingent upon their usefulness. A greater number of individuals will adopt technology if it is both user-friendly and advantageous. The technology's simplicity renders it more appealing to consumers, who are convinced that it can help them achieve their goals. Items that are simple and practical are more likely to be used and appreciated.

It is more probable that frequent users will find a tool to be both simple and useful. When technology is perceived as user-friendly and advantageous, individuals are more inclined to employ it to achieve their desired results. The benefits and ease of use of a tool can influence its long-term use. Technology that is both beneficial and user-friendly is more likely to be retained. Individuals are more inclined to embrace technology because they are convinced that it can help them achieve their goals and is user-friendly. The perceived value of technology is influenced by the perceived ease of technology use, which in turn affects how individuals intend to utilize it and how they do so. This may result in the permanent and widespread integration of the technology. The capabilities of computational thinking are significantly impacted by technological advancements. Individuals who maintain an optimistic attitude towards using are more likely to possess exceptional computational thinking capabilities, according to the research. Research studies and well-established theoretical frameworks, such as the Technology Acceptance Model, provide substantial support for the relationship. A more optimistic perspective on technology has the potential to improve computational thinking capabilities, which in turn can improve academic performance by making technology more readily accessible and engaging.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The first author wrote the paper, assisted in the data analysis, and did all the necessary revisions to comply with the standards of the journal. On the other hand, the second, and third authors facilitated the gathering of data together with the former, assisted in the data analysis. Next, the fourth authors, facilitated the reviewed/edited the final version of the paper. All authors had approved the final version.

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