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PREDICTING KEY FACTORS AFFECTING SECONDARY SCHOOL STUDENTS' COMPUTATIONAL THINKING SKILLS UNDER THE SMART CLASSROOM ENVIRONMENT: EVIDENCE FROM THE SCIENCE COURSE

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Abstract. *The main purpose of this research was to explore the key factors influencing secondary school students' computational thinking skills within the smart classroom environment. Data were collected from 420 students in 4 secondary schools in B city, China. The optimal fitting results of the structural equation model showed that internet attitudes, internet self-efficacy, and internet use are the key factors directly related to students' computational thinking skills. Furthermore, there are indirect effects between students' attitudes towards the internet and computational thinking skills through internet self-efficacy and internet use as mediators. These internet-related characteristics were confirmed to be significantly associated and simultaneously affected their computational thinking skills. After reviewing and reflecting on the research conclusions, this study proposed several measures to improve secondary school students' computational thinking skills while taking into account the complicated interplay of internet psychology and behavior characteristics.*

Keywords: *computational thinking skills, Internet attitude, Internet self-efficacy, Internet use, smart classroom, secondary school students.*

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Introduction

Computational thinking skills (CTS) are becoming the critical skills that should be acquired in this digital age and are important for everyone. They play a significant role in our daily lives as reading, writing, and arithmetic skills (Wing, 2006). Several scholars called on the research field to emphasize computational thinking skills as the key abilities for primary and secondary education, teach across the corresponding curriculum and develop pedagogy (Wing, 2006, 2008). A series of measures are conducted to cultivate students' computational thinking skills, such as programming, cross-curricular activities, and specialized academic curricula. Among these measures, cross-curricular activities are the common approaches to develop students' computational thinking skills. Considering that computational thinking skills are related to computing, crosses curriculum boundaries, and provide a greater manner to rethink and understand acquired knowledge. Only by cultivating them in a rich interdisciplinary environment, the barriers of knowledge and application can be broken down and further provide students with truly new approaches to think and solve problems (Jou et al., 2021). Especially in mathematics, science, information technology curricular activities, they can improve students' computational thinking skills, promote the dual development of subject disciplinary ability and computational thinking skills (Jou et al., 2021; Sengupta et al., 2013). For instance, the Computing at School (CAS) group in the UK promotes the integration of computational thinking into various subjects to improve students' problem-solving abilities (Brown et al., 2014). The government department has already listed computational thinking skills as the key qualities of information technology in some curriculum standards in China (The Ministry of Education of the People's Republic of China, 2017). The related curricula are being implemented in primary and secondary schools to cultivate students' computational thinking skills.

Furthermore, integrating information technology into the learning environment, such as smart classroom, is a popular way to enhance students'

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critical thinking and further promote computational thinking skills through transforming the external study environment (Malik & Shanwal, 2017; Lu et al., 2021). The smart classroom could be seen as an effective implementation to cultivate students' computational thinking skills. Many schools build smart classrooms as innovative study environments that cultivate the students' higher-level thinking ability and help them solve complex problems. In some countries, including China, the relevant government departments have provided a lot of funding to promote the construction of smart classrooms at all school levels (Huang et al., 2012). They issued some policies and emphasized the significance of building a smart study environment for promoting smart education (The Ministry of Education of the People's Republic of China, 2018). Meanwhile, they have launched a series of similar research projects to explore the factors influencing the students' performance and their influencing mechanism in the smart classroom.

Previous research revealed that the smart classroom could greatly improve students' creativity (Malik & Shanwal, 2017) and academic achievement (Phoong et al., 2019). Meanwhile, the students' learning characteristics such as learning styles, learning motivation, and learning strategies (Lee & Choi, 2017; Shen et al., 2014; Taleb & Hassanzadeh, 2015), and internet-related characteristics, specifically internet attitude, internet self-efficacy, and internet use (Peng & Yang, 2021; Sun & Rueda, 2012; Thomas et al., 2019) also have changed under the smart classroom environment. Some researchers investigated the relations between students' learning characteristics (e.g., learning strategy) (Gong et al., 2020), internet-related characteristics (e.g., internet attitude) (Di et al., 2019), and computational thinking skills, and the key factors influencing their higher-order thinking abilities under the smart classroom (Lu et al., 2021).

Nevertheless, the factors on internet psychology and behavior characteristics affecting students' computational thinking skills within the smart classroom environment have not been comprehensively and deeply explored. Without understanding the key factors influencing the students' computational thinking skills and confirming the mechanisms of influence, the targeted teaching activities or models cannot be designed, developed, and implemented to enhance their skills within the smart classroom. This study will explore the impact of internet-related characteristics on students' computational thinking skills within a smart classroom environment.

Theoretical Background

Smart Classroom Environment

The smart classroom is usually described as that technology-rich intelligence classroom environment. It comes with interactive whiteboards, wireless internet, and other smart terminals (Saini & Goel, 2019). The application of these types of equipment contributes to the presentation of teaching content (Manny-Ikan et al., 2011), the access to learning resources (Yi et al., 2021), the interaction among teachers and students (Zhan et al., 2021). Smart classroom environments change the classroom learning atmosphere (Shen et al., 2020), enhance students' collaborative learning (MacLeod et al., 2018). Compared with the traditional technology-enhanced study environment (e.g., teachers adopting a PowerPoint to show the teaching content in class), the students' academic achievements such as science and chemistry have been significantly improved in the smart classroom environment (Jena, 2013; Menon, 2015). Several studies indicated that students' learning behaviors, attitudes, and emotions had already changed significantly (Gupta et al., 2019; Petko et al., 2017; Thomas et al., 2019). Against this background, it seems all the more important to understand the other factors such as internet-related factors (e.g., internet attitude, internet self-efficacy, internet use), mainly because the students' internet-related factors are likely to affect their performance (e.g., computational thinking skills) within the smart classroom.

Computational Thinking Skills

From learning results, computational thinking skills are also summarized as a compound ability that integrates creativity, collaboration, problem-solving, algorithmic thinking, and critical thinking. The aim is to train people to see and resolve practical problems by thinking systematically, correctly, and effectively (Basu et al., 2017; Korkmaz et al., 2017). They are considered the essential components of many international competency models: creativity, communication, and collaboration skills (Vidergor, 2018; Voogt & Roblin, 2012). Given the growing momentous computational thinking skills in daily life, scholars and education managers have attempted to cultivate students' computational thinking skills (Bull et al., 2020). Several approaches have already been tried to enhance students' computational thinking skills, such as educational robotics activities (Atmatzidou & Demetriadis, 2016), visual pro-

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gramming (Gardeli & Spyros, 2017), and game-based smart toys (Lin et al., 2020). Additionally, based on the math, science, and information teaching course, some cross-curricular activities were carried out to enhance computational thinking skills (Jou et al., 2021; Rich et al., 2020). Meanwhile, scholars have already explored the factors affecting the students' computational thinking skills in these different courses (Pérez-Marín et al., 2020; Rich et al., 2020).

In recent research, the relations between students' computational thinking skills and some variables are replete with studies investigating influencing factors on internet-related psychology and behavior characteristics. For instance, several scholars analyzed the relation of students' computational thinking skills and experience in using information technology (e.g., internet use) (Durak & Saritepeci, 2018), cognitive factors (e.g., self-efficacy) (Román-González et al., 2018), educational level (Özgür, 2020). As previously heightened, within the smart classroom environment, it seems more important to focus on the correlations between psychological characteristics (e.g., internet attitude and internet self-efficacy), internet behavior characteristics (e.g., internet use), and students' computational thinking skills.

Internet Attitude

Internet attitude is defined as feelings, thoughts, and experiences of using the internet (Tsai et al., 2001). Generally, it involves positive and negative categories. Positively, learners considered the internet beneficial for individuals, while the frequency of its actual use in their study is high (Wu & Tsai, 2006). Negatively, they may differ in the degree to which they consider that the internet is useless for analysis, is uncomfortable and anxious, and cannot offer other benefits for their study (Pamuk & Peker, 2009). Internet attitude can predict individual use, beliefs, perceptions, or in other words, it is an important predictor of the internet knowledge and ability (Blank & Lutz, 2016), since attitude is a dominant factor in understanding human behavior (Ajzen & Fishbein, 1977). The previous studies indicated that students' internet attitude might influence internet use (Jackson et al., 2003), internet self-efficacy (Peng et al., 2006), and achievement (Abdullah et al., 2015). Meanwhile, research indicated that students' attitudes towards the internet could affect higher-order thinking within technology-rich environments (Lee & Choi, 2017). Thus, attitudes towards the internet may play a critical role in promoting skills and diversity of use in the smart classroom environment.

Internet Self-efficacy

Internet self-efficacy is the belief that one person organizes and performs internet-related behaviors for completing the required assignments (Eastin & LaRose, 2000). Although internet self-efficacy cannot demonstrate practical competence, it is a strong predictor of behavior changes until the result announcement (Joo et al., 2000). A previous study suggested that internet self-efficacy could significantly predict internet-related skills (Torkzadeh et al., 2006). A recent study indicated that students' internet self-efficacy affected their competence to operate internet documents (Zhao et al., 2010). Meanwhile, the internet psychology characteristic, such as internet attitude, could predict the internet self-efficacy belief system (Wu & Tsai, 2006). Other scholars also found that internet attitude can directly predict students' internet self-efficacy (Shen et al., 2014). One study revealed that students' internet self-efficacy can predict their study motivations (Liang & Wu, 2010) and satisfaction with online education courses (Kuo et al., 2014). Additionally, Peng and Yang (2021)'s research suggested that students' internet self-efficacy could act as the positive intermediary role between internet attitude and performance. Therefore, internet self-efficacy might play a critical role in cultivating internet-related skills.

Internet Use

Internet use is a common term, but there is no actual definition. In essence, it can be considered a series of behaviors about surfing the internet, visiting websites, searching for information in a specific environment (Anderson & Tracey, 2001). Previous research studies have looked at internet use and investigated its antecedents and consequences. Studies reported that personal background, such as age and gender, have a certain connection with internet use (Paul & Shim, 2008). In addition, students' internet attitudes are a momentous predictor of their internet use, including the use of frequency, intensity, purpose, and variety (Cheung & Huang, 2005). Previous research indicated that internet use is a vital factor for predicting students' studies and skills (Judi et al., 2011). A recent study revealed that technical experience is the antecedent of internet use, such as basic computer knowl-

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edge and information technology processing skills, which can positively impact the acceptance and perceived usefulness of the internet (König et al., 2018). Meanwhile, Rozgonjuk and Täht (2017) also suggested that increasing internet use both within and outside of school would ultimately enhance students' academic performance and information technology abilities.

Hypotheses of the Research

Computational thinking skills are also considered the processes of an individuals' knowledge, perceived attitudes of the computer system, internet identification, re-model self-efficacy, and behavior to recognize the world around us by applying the computational tools and technology (Song et al., 2021). Bandura's theory has been widely used to study internet perception, behavior, and skills. This theory emphasizes the interaction between personal motivation beliefs and the external environment, explains the complexity, dynamics, and developmental characteristics of an individual's competencies (Bandura, 1977). Psychological studies have already explained the relations between attitudes, intentions, and beliefs. The influence of psychology internet-related characteristics (e.g., internet attitude, internet self-efficacy) and internet-related behavior (e.g., internet use) on computational thinking skills also need to be effectively explained. Therefore, this research attempted to analyze the influence of internet attitude, internet self-efficacy, and internet use on students' computational thinking skills and further confirmed this mechanism of the factors mentioned above within the smart classroom environment.

Previous research has found that the internet attitude is considered a vital predictor for technology adoption (Teo et al., 2008). An individuals' internet attitude is closely related to internet behavior. Chou et al. (2016)'s study indicated that individuals' attitude towards the internet could significantly affect their information retrieval and communication. Thus, the present study hypothesized that students with positive attitudes towards the internet are more likely to participate in internet activities in smart classrooms (Hypotheses 1).

A study showed that no matter what the technology is implemented, the attitude towards the internet can impact learners' internet self-efficacy and engagement (Hopson et al., 2001). Wu and Tsai (2006) observed that students' internet attitudes could explain several aspects of their internet self-efficacy. In the context of the smart classroom environment, students' attitudes towards the internet are likely to be positively related to their self-efficacy. Therefore, the present study hypothesized that students' internet attitudes would directly and positively affect their internet self-efficacy (Hypothesis 2).

Previous research indicated that self-efficacy is important for developing an individual's computer skills (Efe, 2015). A personal internet self-efficacy is related to his creativity, and the improvement of self-efficacy can promote creativity to a certain extent (Wu et al., 2017). As we all know, internet self-efficacy is a kind of self-efficacy. Meanwhile, creativity is a vital component of computational thinking skills (Korkmaz et al., 2017). Therefore, individual internet self-efficacy may affect their computational thinking skills under certain conditions. Specifically, this study hypothesized that students' internet self-efficacy could directly and positively affect their computational thinking skills in smart classrooms (Hypothesis 3).

Previous research found out that the daily use of the internet positively affected the students' creative abilities (Wu et al., 2017), further revealed that increasing internet use would ultimately improve computational thinking skills (Durak & Saritepeci, 2018). Under the smart classroom environment, students' experience with information technology, and interaction preferences may positively affect their computational thinking skills. Against this background, the present study assumed that students' internet use might affect their computational thinking skills with the smart classroom (Hypothesis 4).

Previous research suggested that students' internet attitudes can significantly affect their study and skills in the information technology study environment (Judi et al., 2011). Other studies have revealed that actual learning outcomes rely on the students' internet attitudes (Abdullah et al. 2015). The research indicated that students' attitude towards the internet directly influenced their critical and innovative thinking within the smart classroom (Di et al. 2019). According to Korkmaz et al. (2017)'s research, computational thinking skills contain critical thinking and innovative thinking skills. Therefore, this research assumed that students' internet attitudes could directly and positively affect computational thinking skills in the smart classroom environment (Hypothesis 5).

Based on social psychology, the internet psychology characteristic, such as internet self-efficacy, could predict internet use (Tsai et al., 2001). The students' internet self-efficacy positively predicts their online entertainment activities (Prior et al., 2016). Therefore, this research assumed that internet self-efficacy could directly and positively affect the students' use of the internet for studying in the smart classroom (Hypothesis 6).

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This research proposed six hypotheses, constructed a model of influencing factors related to computational thinking skills, as shown in Table 1 and

Figure **1**, and adopted the Structural Equation Model [SEM] to examine in the smart classroom environment: 1) Whether internet attitude, internet self-efficacy, and internet use can influence students' computational thinking skills? 2) Can students' internet self-efficacy or internet use play an important intermediary role between internet attitudes and computational thinking skills?

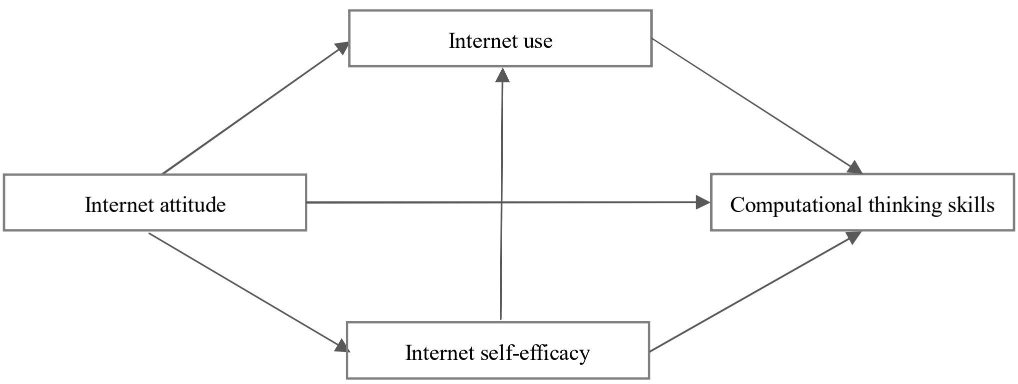
Table 1

Hypothesized Relations between Students' Internet Attitudes, Internet Self-efficacy, Internet Use, and Computational Thinking Skills

Hypothesized 1 (H1)	Internet attitudes can directly and positively affect students' internet use.
Hypothesized 2 (H2)	Internet attitudes can directly and positively affect students' internet self-efficacy.
Hypothesized 3 (H3)	Internet self-efficacy can directly and positively affect students' computational thinking skills.
Hypothesized 4 (H4)	Internet use can directly and positively affect students' computational thinking skills.
Hypothesized 5 (H5)	Internet attitudes can directly and positively affect students' computational thinking skills.
Hypothesized 6 (H6)	Internet self-efficacy can directly and positively affect students' computational thinking skills.

Figure 1

The Structural Model of Influencing Factors of Computational Thinking Skills within the Smart Classroom Environment



Research Methodology

General Background

To test the hypotheses regarding the effects of internet attitudes, internet self-efficacy, and internet use on predicting secondary school students' computation thinking skills in the smart classroom environment, a survey was employed, and quantitative data were collected using reliable measurement tools. The quantitative data were collected in the science courses at specific secondary schools. The main reasons for choosing this course and schools are as follows. First, China's Ministry of Education required that the science courses be included in the compulsory curriculum for secondary school students, and each class is required to have science courses a week (The Ministry of Education of the People's Republic of China, 2000). Second, these schools attach importance to the application of information technology, and each school has set up at least three smart classrooms. All teachers at these schools have trained and studied smart classrooms for teaching activities for two years.

This research was carried out in spring semester of the academic year 2021 from the selected schools. In every school selected, there are 20 weeks in this semester. Science teachers and students meet one time a week for daily teaching. All science courses were offered the same learning and instrument materials. The participated students were required to use information terminals for carrying out science courses in the smart classroom.

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Sample

The total participants contained 505 students enrolled in this survey at 4 secondary schools in B city, China. The main reasons for choosing this sample were as follows. Firstly, the average age of the participants was higher than 13 years. This indicated that they own a high level of judgment on the scale items for providing an accurate response. Secondly, these students have already participated in the total two-semester learning experience, and all classes were carried out in traditional multimedia classrooms. Thus, they had no learning experience within smart classrooms environment before that. It was noted that in this study, these students from 8th grade secondary schools have a relatively light academic burden.

These students were selected using cluster sampling. All of them were willing to participate in this survey and fill in the relevant survey questionnaire carefully within the specified time. After the questionnaires were collected, invalid questionnaires were deleted during the data analysis. The 420 valid questionnaires were reserved at last, and the recovery rate was 83.17%. The demographic information of these students indicated that 53.71% (n=226) of the participants were male, and 46.29% (n=194) were female. The average age of these students was 13.22, and the standard deviation [SD] was .76. The percentage of these students who stated their internet experience was less than 1 year was 6.65%, while between 1-3, 3-5, and more than 5 years were 19.44%, 26.09%, and 47.83%, respectively.

Instruments and Procedure

The previous mature instruments were utilized in the present research. The "back-translation" was adopted to develop these instruments (Douglas & Craig, 2007). Firstly, these instruments were translated from English to Chinese; secondly, another translator translated the above version into English; thirdly, native English speakers were required to contrast and correct the initial instruments with this reverse translation (Behling & Law, 2000). Given that the initial instruments were translated and adapted in the different educational backgrounds, the reliability and validity of each instrument should be tested in detail.

The questionnaire included two parts. The first part was about demographics such as sex, age, and internet experience. The second part contained four scales: computational thinking skills, internet self-efficacy, internet attitude, and internet use. With the consent of school leaders and teachers, these questionnaires were handed out to all participating students. This survey was anonymous, and the confidentiality of the participants was ensured. To reduce the measurement error and ensure the quality of these questionnaires, all participants were required to complete the questionnaires during science courses, and their confusion in filling out the questionnaires can be explained by the researchers in charge of the present study.

The computational thinking skills scale was exploited to assess the levels of the individuals' computational thinking skills. It contained five parts: creativity, collaboration, problem-solving, algorithmic thinking, and critical thinking (Korkmaz et al., 2016). The scale contained twenty-two items, and all items used a 5-point Likert scale ranging from 1 (*never*) to 5 (*always*). Items in the scale include: "I like people who believe most of their decisions are right." and "I am willing to learn challenging things." In the present research, confirmatory factor analysis [CFA] was used to test the factor structure of this scale, after which thirteen items were kept. Cronbach's α value of the total scale was .951. Items with factor loadings between .567 and .813 were retained. The fit index values were Comparative Fit Index [CFI] = .988, Incremental Fit Index [IFI] = .988, Root Mean Square Error of Approximation [RMSEA] = .053, Tucker & Lewis Fit Index [TLI] = .980. This result revealed that this model fit index was satisfactory.

Internet attitude scale was adopted to measure students' attitudes towards the internet. This scale consisted of twenty items, and all items were marked using a 5-point Likert scale ranging from1 (*strongly disagree*) to 5 (*strongly agree*) (Durndell & Haag, 2002). Items in the scale contain: "I am terrified of the internet" and "People are becoming slaves to the internet." The CFA was adopted to test the scale's factor structure, after which seven items were kept. Cronbach's α value of the entire scale was .920. Items with factor loadings between .643 and .881 were retained. The fit index values were CFI = .999, IFI = .999, RMSEA = .034, TLI = .995. All these showed that this model fit index was at the acceptability level.

The internet self-efficacy scale was adopted to assess the degree of personal confidence in using the internet (Tsai, 2004). This initial scale consisted of thirteen items, scoring between 1 (*not confident at all*) and 4 (*very much confident*) using a 4-point Likert scale. Items in this scale include: "I can get the information I need" and "I was able to buy books from Amazon.com." The CFA was used to test the factor structure of the scale, after which nine items were kept, and factor loads of items between .652 and .949 were retained. Cronbach's α value of the overall scale

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was .949. The fit index values were CFI = .996, IFI = .996, RMSEA = .045, TLI = .992. This result demonstrated that the model fit index was at an acceptable and desired level.

The internet use scale was used to measure the frequency and time of students' internet use (Joiner et al., 2007). The scale contained fifteen items, scored between 1 (*strongly disagree*) and 5 (*strongly agree*) using the 5-point Likert scale. Items in the scale include: "Adopt software to search and remove viruses" and "Search for and find a file on a computer." The CFA was used to test the factor structure of the scale, after which fourteen items were kept. Cronbach's α value of the whole scale was .956. Items with factor loadings between .662 and .868, and the fit index values were CFI = .988, IFI = .988, RMSEA = .056, TLI = .977. All these indicated that this model fit index was at an acceptable level.

Data Analysis

The process of data analysis in this study was as follows. First of all, the reliability and validity were analyzed. Cronbach's α was adopted to measure the reliability of each scale. CFA measured the structure and convergence validity of the scales. The discriminant validity was measured by judging whether the correlation coefficient between dimensions was less than the construct's square root of structure average variance extracted [AVE]. Secondly, the Harman single-factor test was carried out to make sure no serious common variance deviation in the present study (Podsakoff et al., 2003). The structural equation model was constructed, and the goodness of fit indexes was used to judge the fitting degree of the model. The p-value was adopted to determine whether the direct influence of internet attitude, internet self-efficacy, and internet use on computational thinking skills were significant. The standardized path coefficient (β) was used to analyze the sizes of the impacts based on the method of maximum likelihood estimation. In the end, the Bootstrap mediation test with the 95% confidence interval of 0 was adopted to measure whether the indirect effects of internet self-efficacy and internet use on computational thinking skills was significant and the size of the total effect. Besides, the percentage (%), average, and SD were adopted to describe the importance of parameters based on their properties. All the above-mentioned statistical processing and analyses were performed in the SPSS 26.0 and AMOS 26.0 for Windows.

Research Results

Since all variables in this study were self-reported by students, there may be a problem of common variance deviation. Given this, the Harman single-factor test was used to measure the severity for common variance deviation (Podsakoff et al., 2003). The result revealed that the variance explanation percentage of the first common factor is 36.31%, which is lower than below 50% judgment standard recommended by Hair et al. (2014). It can be concluded that the data in this study will not affect the research results due to common variance deviation.

Assessment of the Measurement Model

The measurement model in the present research was mainly represented by item reliability, convergence validity, and discriminant validity. Precisely, the reliability coefficients and convergence validity were measured by Cronbach's α, and AVE, respectively. Table 2 illustrated that all values of Cronbach's α were greater than .920. Also, Cronbach's α of the scales exceeded .8, which was acceptable (Hair et al., 2010). Composite reliability [CR] of all constructs were .918 and .954, and all were above the required cut-off value of .6, which suggested that the items of each construct had a satisfactory internal consistency (Bagozzi & Yi, 1988). All AVE values were higher than .567, which met the required standard value of .5 (Fornell & Larcker, 1981). The square root AVE of each construct was higher than their correlation coefficients, which suggested that the discriminant validity of this measurement model was good in the present study.

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Table 2
Reliability and Validity Analysis

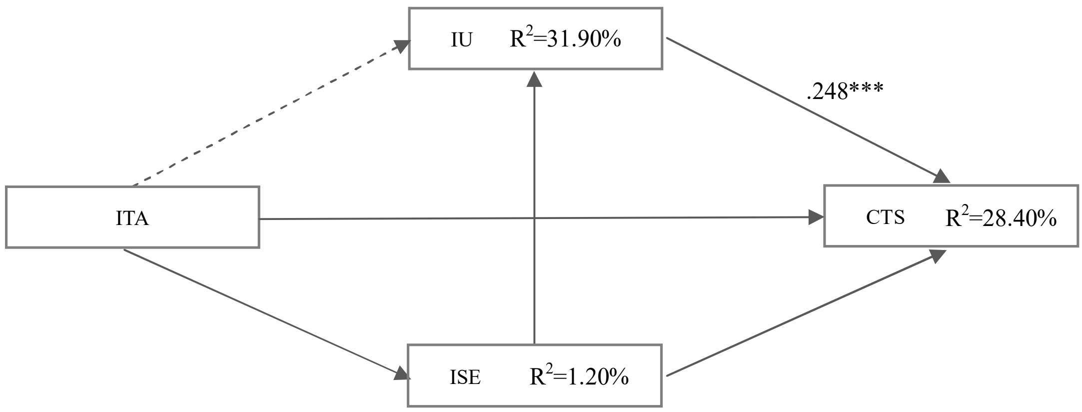
Construct	Reliability		Convergent validity	Discriminant validity			
	α	CR	AVE	CTS	ISE	ITA	IU
CTS	.951	.944	.567	.753			
ISE	.949	.952	.691	.440	.831		
ITA	.920	.918	.619	.175	.105	.787	
IU	.956	.954	.596	.413	.531	.140	.772

Note: CTS: computational thinking skills, ISE: internet self-efficacy, ITA: internet attitude, IU: internet use

Assessment of Structural Model

The present research adopted the chi-square value by degrees of freedom (*χ2/df*), RMSEA, CFI, TLI, and standardized root mean square residual [SRMR] to evaluate this structural model. The cut-off values required by the model fitting indexes are *χ2/df* < 3, RMSEA < .08, CFI > .90, TLI > .90, and SRMR < .08 (Hu & Bentler, 1999). The SEM showed that this hypothesis model had good fitting data: *χ2/df* = 1.931, RMSEA = .047, CFI = .956, TLI = .950, SRMR = .073. The hypothesis model's path coefficient (*β*) and test results were presented in Figure 2. This result indicated that five of the six hypotheses were statistically significant. The results demonstrated that internet attitude predicated effect on internet use was insignificant (*β* = .067, *t* = 1.495, *p*>.05). While, internet attitude significantly predicted internet self-efficacy (*β* = .109, *t* = 2.220, *p*<.05). Hence, Hypothesis 1 was not supported, but Hypothesis 2 was supported. Computational thinking skills were driven by internet self-efficacy (*β* = .327, *t* = 5.568, *p* < .001), internet use (*β* = .248, *t* = 4.254, *p* < .001), and internet attitude (*β* = .103, *t* = 2.194, *p*<.05). It was worth noting that among the factors influencing computational thinking skills, internet self-efficacy had the greatest significant impact on computational thinking skills. Therefore, Hypothesis 3, Hypothesis 4, and Hypothesis 5 were supported. Internet self-efficacy positive statistically significantly predicted internet use (*β* = .554, *t* = 10.439, *p*<.001). Therefore, Hypothesis 6 was supported. The structural model was also evaluated by calculating the R2 value. According to Hair et al. (2011)'s suggestions, R2 values that should be resulted in SEM are 75% (substantial), 50% (moderate), and 25% (weak). The R2 value of internet self-efficacy, internet use, and computational thinking skills ranged from 1.2% to 31.9%. It can be understood that the R2 of this study was at the lower level of "moderate".

Figure 2
Path Coefficient of the Hypothesized Model



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Mediating Effect Analysis

Effect analysis was used to figure out the internet psychology and behavior factors that affect computational thinking skills. The significant positive impact of internet attitude on computational thinking skills, internet attitude on internet self-efficacy, internet self-efficacy on internet use, and internet self-efficacy on computational thinking skills were observed.

Thus, the bootstrap test was adopted to sample 2000 times at a 95% confidence level to test the mediating effect of internet self-efficacy and internet use on computational thinking skills. The mediation test results for the model were shown in Table 3. The internet attitude on the secondary school students' computational thinking skills included one direct path and two indirect paths. The indirect effect of internet attitude on computational thinking skills is 32.95% of the total effect. Internet self-efficacy played a partially mediating role between internet attitude and computational thinking skills. Additionally, an indirect effect was found between internet self-efficacy and computational thinking skills. The calculation results showed that the indirect effect of internet self-efficacy on computational thinking skills accounted for 29.59% of the total effect. Therefore, internet use played a partially mediating role between internet self-efficacy and computational thinking skills.

Table 3
Indirect and Total Effects Analysis among Variables

Path		Effect value		Account (Indirect /total)
ITA→CTS				32.95%
Direct effect	ITA→CTS		.103	
Indirect effect	ITA→ISE→CTS	.109*.327 = .036	.051	
	ITA→ISE→IU→CTS	.109*.554*.248 = .015		
Total effect			.154	
ISE→CTS				29.59%
Direct effect	ISE→CTS		.327	
Indirect effect	ISE→IU→CTS	.554*.248 = .137	.137	
Total effect			.464	

Discussion

This study explored the factors contributing to the secondary school students' computational thinking skills in science courses under the smart classroom environment. The SEM was adopted to test their correlations, students' internet attitudes, internet self-efficacy, internet use, and computational thinking skills. First, internet attitude, internet self-efficacy, and internet use could positively predict students' computational thinking skills, which was consistent with many studies (Durak & Saritepeci, 2018; Kuo & Belland, 2019; Román-González et al., 2018). Besides, the direct effect of internet attitude on internet use was not significant. This study yielded inconsistent findings with previous research claiming that students' internet attitudes can predict their internet use (Tsai et al., 2001). The probability reason is that students are already familiar with the ubiquitous learning environment of classrooms covered by the internet. The internet has become a fundamental tool for students' daily study. As we all know, there are many advanced technologies in smart classrooms. Compared to the internet, advanced technology such as clarity and stability presumably stimulated internet use and encouraged students to carry out some related internet use activities during the science course. All these may decrease the related internet use activities, which could, to some extent, account for the weak connection between internet use and internet attitude in the science course.

As for the result of direct effect, students' computational thinking skills are directly influenced by their internet attitudes, internet self-efficacy, and internet use. The present result revealed that the factors related to students' internet psychology and behavior characteristics were the closest factors influencing their computational thinking

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skills. The previous studies, such as Román-González et al. (2018), Alsancak (2020), and Román-González et al. (2017), did not distinguish the degree effect of the influencing factors and the mechanism. Román-González et al. (2018)'s research indicated that there was a statistically significant correlation between computational thinking skills and internet self-efficacy. Similarly, Román-González et al. (2017) and Alsancak (2020) also found that students' internet recognition and perceived use can significantly affect their perceived usefulness and behavior of the internet, and finally influence their computational thinking skills. The present research indicated that students' internet self-efficacy and internet use played a role between internet attitudes and computational thinking skills, and the mechanism effect of internet self-efficacy was relatively significant. A probable reason is that the students' perceived usefulness, affect, control, and behavior have already variated in the smart classroom (Gupta et al., 2019; Shen et al., 2020), which might change the degree of the influencing factors and mechanisms between them. Specifically, under the smart classroom environment, the students perceived the usefulness of the enrich-technology, and they were confident to use the internet for studying. That's up to a point can change their preference or tendencies, facilitate interaction, improve collaboration abilities, and finally develop computational thinking skills (MacLeod et al., 2018; Mantooth et al., 2021).

Furthermore, students' internet attitude also indirectly affected their computational thinking skills, and internet self-efficacy and internet use were the intermediaries between internet attitudes and computational thinking skills. Although internet attitude played a primary role in most studies, such as Durak and Saritepeci (2018), Kuo and Belland (2019), few studies also found that internet attitude indirectly affected computational thinking skills. Tsai et al. (2011) suggested that internet attitudes had the least impact on students' internet-related skills compared to other internet characteristics. As we all know, computational thinking skills are the critical skills for students, which may also be influenced by other psychology and behavior characteristics in the smart classroom environment, such as internet use or self-efficacy. Another probable reason may be that the students' autonomy can be strengthened since mobile terminals obtained effective support with new learning experiences in the smart classroom environment (Zhan et al., 2021). Smart classroom environments trigger the increase of students' autonomous behavior and student-driven teacher conversation, to some extent, which increases students' ability to solve problems independently and communicate with others, and ultimately improves their computational thinking skills (Zhan et al., 2021; Zhang et al., 2019).

Conclusion and Implications

This research proposed a model with antecedents of the secondary school students' internet attitude, internet self-efficacy, internet use, and computational thinking skills in science courses under the smart classroom environment. This model was developed based on recent research regarding the relations between internet attitude, internet self-efficacy, internet use, and computational thinking skills of secondary school students. The model contained six hypotheses, and our analyses indicated that five of these six hypotheses were supported by this survey data.

This current study also revealed that internet attitudes, internet self-efficacy, and internet use were the main factors directly affecting secondary school students' computational thinking skills within the smart classroom environment. It was worth noting that these students' internet self-efficacy and internet use could play a positive intermediary role between their internet attitude and computational thinking skills. Different from these traditional technology-enriched classrooms in previous studies, it was found that internet attitude can significantly predict their internet self-efficacy and computational thinking skills. Meanwhile, internet attitudes could indirectly enhance computational thinking skills by influencing their internet self-efficacy and use. Students' internet attitudes and internet self-efficacy can be more significant to stimulate the perceived ease of internet use, increase the frequency of internet use for communication and study, further enhance the cooperation and problem-solving skills to improve their computational thinking skills within the smart classroom.

According to this study's findings, some practical suggestions can be adopted to cultivate the students' computational thinking skills in the smart classroom. Considering the interweaving of skills and self-efficacy, the students' computational thinking skills can be enhanced by improving their internet self-efficacy. It can be said that cultivating students' internet self-efficacy is the most effective approach to improve their computational thinking skills. This suggested that cultivating students' internet self-efficacy in specific learning tasks would improve their computational thinking skills under the smart classroom environment. Thus, suggestions should be provided that teachers should understand secondary school students' internet self-efficacy before the science courses begin and provide several methods/aids with low internet self-efficacy for helping them comprehensively improve their computational thinking skills.

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Meanwhile, the learning experience can serve as a powerful motivator for changing their feelings, thoughts, preferences, and internet-related skills in the smart classroom environment. Specifically, secondary school students should be provided with a more profound learning experience to gradually change their internet attitudes and improve their use for learning, communication, and entertainment. However, simply changing students' internet attitudes may not bring the desired results immediately. Consistency between internet attitudes, internet self-efficacy, and internet use will serve as a power-hot intervention to enable students to learn innovation, problem-solving and critical thinking, and be prepared to solve complex and open-ended problems, further enhance computational thinking skills. Such meaningful and coherent learning experiences could contain related learning activities or appropriate technologies for the purpose of promoting internet self-efficacy and increasing internet usage. In other words, activities that let students feel individual satisfaction by deeply participating in learning inquiry and tasks that require them to integrate learning activities such as creativity or problem-solving ability and further improve their computational thinking skills.

Limitations and Directions for Future Research

Several limitations provide opportunities for future study in the present research. Firstly, the present research adopted a cross-section research design. Students' internet-related psychology and behavior characteristics under the smart classroom environment may change over time, so the cross-section method adopted here has a certain limitation. Future studies may attempt to better clarify these fluctuations by longitudinal investigations of possible changes. Secondly, the current study did not consider the influence of demographic variables and other personality characteristics. Therefore, further studies could contain some demographic variables, such as grade and human personality since students' computational thinking skills may be related to them under the smart classroom environment. Thirdly, this study adopted just self-reports to gather data on students' internet attitude, internet self-efficacy, internet use, and computational thinking skills. Although these scales adopted in the current study were valid and reliable, collecting data from the same respondents just by self-reports may lead to bias of self-exaggeration or self-derogatory. In further studies, more objective and clinical measures could be adopted to explore the mechanism of the above factors within the smart classroom environment.

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Declaration of Interest

The authors declare no competing interest.

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