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Investigation of the Relationship Between teachers' Computational Thinking Self-Efficacy and their Attitudes Towards Use of Computational Thinking Skills

Naif Adeeb Al-Otaibi

Professor, Department of Curricula and Instruction, College of Education, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia. nalotaibi@iau.edu.sa
https://orcid.org/0000-0001-6709-947X

Abstract:

This study aims to determine the levels of teachers' self-efficacy in computational thinking and attitudes toward using computational thinking skills. It also investigates the relationship between computational thinking self-efficacy and attitudes toward using CT skills. To achieve these objectives, the descriptive correlational approach was utilized. The study sample consisted of (320) teachers from Saudi Arabia. The study tools are a computational thinking self-efficacy scale and attitudes toward using computational thinking skills scale. The results revealed a medium level of teachers' computational thinking self-efficacy and attitudes toward using CT skills. In addition, there is a statistically significant relationship between teachers' computational thinking self-efficacy and attitudes toward using CT skills. In light of the results, the current study suggests developing and implementing educational interventions that enhance teachers' computational thinking self-efficacy and positive attitudes toward using computational thinking and incorporating non-cognitive aspects related to computational thinking into teacher preparation programs..

Keywords: Professional Self-efficacy, Professional Identity, Attitude towards Using Technological Innovations, Teachers.

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1. Introduction

Computers have become an integral part of the public's everyday lives and the capacity to use them effectively is a valuable skill that helps individuals manage their daily activities and solve problems (Barr et al., 2011). As a result, integrating digital technology into the educational field has been viewed as a cultural process, rather than just the introduction of tools. These technologies have become an integral part of an individual's culture, enabling them to practice different thinking styles, such as abstract, innovative, critical thinking, and problem-solving (Grover & Pea, 2013). Consequently, the acquisition of twenty first-century competencies in education and the recognition of students as digital citizens require the development of these thinking styles, to the acquisition of social, cultural, productivity, responsibility, leadership, and computational thinking skills (Yen et al., 2012).

Computational thinking (CT) is a new and basic way of thinking and fixing issues that can be carried out throughout numerous disciplines, such as economics, art, and the understanding of human behavior (Bundy, 2007; Wing, 2006). CT is increasingly recognized as a critical 21st century ability that goes beyond just using computers to teach students the process of abstract thinking, algorithmic thinking, collaboration, critical thinking, and hassle-fixing (Rich et al., 2021; Moore et al., 2020; Hou et al., 2020; Ching et al., 2018). It represents a manner of thinking that involves using computer science ideas to solve complex issues (Yadav et al, 2014). This type of analytical thinking allows students to utilize mathematical thinking to apprehend and resolve complicated issues (Wing, 2006).

CT is a trouble-fixing procedure or process that involves analyzing troubles or problems, breaking them down into manageable parts, and coherently modeling the overall problem (Astrachan, 2009). It is associated with higher thinking skills such as collaboration, creativity, and critical thinking (Kukul & Karatas, 2019; García-Peñalvo, 2016; Korkmaz et al. al., 2017; Lawanto et al., 2017; Lye & Koh, 2014; Wing, 2010). Thus, it represents a necessary skill for STEM-related fields and is deemed essential for success in Future professional life (Avcu & Ayverdi, 2020; Yadav et al., 2017).

The integration of computer technology and CT skills into school curricula has made it crucial for teachers to be prepared to incorporate these skills into their teaching and to continuously reflect on and develop their pedagogical practices (Nordén et al., 2017). This is particularly important as technological advancements, such as automation, artificial intelligence, huge information, and robotics, have become integral parts of daily human activities (Fukuyama, 2018).

Studies indicate that the decline in students' CT skills can be attributed to teacher's lack of ability to develop these skills, and their limited understanding of them (Angeli & Giannakos, 2020; Gadanidis, et al., 2017; Weintrop et al 2016). As a result, current efforts have focused on improving teachers' understanding of CT and raising awareness of its importance across various aspects of life (Blum and Cortina, 2007).

One of the key factors that enhance the development of students' CT skills is the teacher's self-efficacy in CT. A teacher with high self-efficacy positively affects student learning and the construction of new competencies (John A Ross et al., 2001; Erik et al., 2011). Strong self-efficacy in digital competencies enables the teacher to implement curricula that include CT skills and computational and digital competencies (Nordén, et al., 2017). Therefore, CT self-efficacy is one of the vital variables for learning these skills.

According to Özmen and Altun (2014), one of the reasons for teachers' failure in programming and students' difficulties in developing programming skills is the lack of practice, knowledge, and low self-efficacy. They also indicated that teacher's high perceptions of self-efficacy positively affect their performance in CT skills.

Similarly, Talsma et al., (2018) advised that the difficulty in learning and practicing CT skills can be attributed to a decrease in self-efficacy. It represents a strong motivator for learning and practicing CT skills (Malone & Lepper, 2021; Murnieks et al., 2020; Yildiz-Durak, 2018). Consequently, recent research has primarily focused on exploring the variables related to self-efficacy and its relationship to computational performance (Kong et al., 2018 Yang & Cheng, 2009; Cassidy & Eachus, 2002).

Additionally, attitudes are also recognized as factors that enhance the use of CT skills. Richado et al., (2023) indicated that attitudes have a big effect on the use of CT skills. Similarly, Yadav et al., (2014) found that introducing CT into teacher preparation programs successfully has an impact on pre-service understanding of CT elements and it affects attitudes toward computing.

Many studies have emphasized the importance of enhancing attitudes toward using CT and strengthening the correlation between attitudes toward using CT skills (Perdana et.al., 2021; Korkmaz & Xuemei, 2019; Richardo & Martyanti, 2019). Morreale and Joiner (2011) discovered that the advent of computational ideas and concepts changed teachers' perceptions of computer science as an educational tool and that teachers' knowledge of CT can shape their attitudes toward using it as an input for solving complex problems (Barr and Stephenson 2011). This finding is consistent with previous studies that indicates a statistically significant relationship between attitudes toward CT and its skills (Hava & Koyunlu Ünlü, 2021; Cutumisu et al., 2021), and that attitudes affect teachers' CT skills (Cutumisu et al., 2021).

According to Richado et al., (2023), investigating the attitudes toward CT and their effects on the use of CT skills is still limited. Although some studies have explored CT skills and self-efficacy, there may be a loss of sufficient studies that focus on self-efficacy in CT and the attitude toward using CT skills, and investigating the connection among them.

2. Research questions

This study aims to decide the levels of teachers’ self-efficacy in CT and the attitude toward using CT skills, as well as investigate the relationship between CT self-efficacy and the attitude toward using CT skills. To achieve this objective, the current study raises the following questions:

1. What is the level of teachers’ CT self-efficacy?
2. What is the level of teachers’ attitudes toward using CT skills?
3. Is there a statistically significant relationship between teachers’ CT self-efficacy and their attitudes toward using CT skills?

3. Theoretical Overview of the Main Concepts

Computational thinking skills

People living in a technology-rich society need three different skills to survive in the 21st century: the ability to use basic computer applications; this is generally known as computer literacy. The second is the ability to understand how computer systems work. The third is the ability to use computer technologies or applications to solve specific problems. This skill is now known as computational thinking (Dickerson, 2019).

Computational thinking (CT) is described as the mental interest and activity of deriving issues or problems and formulating solutions that can be addressed automatically (de Jesusi & Silveira 2022; Yadav et al., 2014). It represents a combination of other thinking patterns, such as abstract thinking that helps in facing the problem through drawing shapes and building simpler representations of abstract representations, logical thinking that leads to reaching a logical conclusion to the problem and modeling thinking that leads to translating things or phenomena in the actual world into Mathematical equations and models, or simulation models and computer relationships (Liu & Wang, 2010).

Computational thinking focuses on students' procedural thinking processes when formulating troubles and problems, compiling solutions within the shape of algorithms, and locating positive patterns in solving the troubles (Román-González et al., 2017).

CT is a vital skill because it integrates elements of mathematical, engineering, and scientific thinking and includes a set of basic skills such as analysis and Composition (Aho, 2012; Wing, 2008). Dickerson (2019) identified computational thinking skills to include algorithmic thinking; abstraction; hassle decomposition, facts and data collection, illustration and analysis, evaluation, parallelization, control flow, incremental and iterative; checking out and debugging; and wondering.

Wing (2008) discussed the importance of CT skills throughout more than one discipline; it allows students to acquire new problem-solving techniques and discover new solutions for the actual and digital world. It also enhances creative thinking, introduces new ways of viewing social and natural phenomena (Miller et al., 2013; Settle et al., 2012), and significantly improves students’ attitudes toward future computing courses (Dickerson, 2019).

Therefore, it becomes important to combine CT skills into the educational curricula (Pewkam & Chamrat, 2022; Nordén et al., 2017), and for the teacher to have confidence and digital competencies such as CT self-efficacy. This allows them to plan their educational activities and be prepared to integrate these skills into their teaching, as well as enhance attitudes toward using CT skills (Nordén et al., 2017).

Computational Thinking Self-Efficacy

Social Cognitive Theory indicates that self-efficacy is related to an person’s beliefs and motivations (Bandura, 1977). Self-Efficacy expresses an person’s confidence in his capacity to prepare and carry out required workflows, gain a particular goal, or solve a problem (Yang & Cheng, 2009). It indicates the extent to which individuals persevere when facing difficult tasks and their flexibility in dealing with difficulty or failure (Schunk et al., 2014; Nordén et al., 2017).

Self-Efficacy also represents the individual’s belief that his abilities can control their level of performance

(Bandura, 1993), and their belief in success in solving complex problems and creating a positive mental state to face complex situations (Safari et al., 2020).

Self-efficacy is related to concepts such as academic success, motivation, self-regulation, knowledge, and self-management (Zimmerman, 2000), and acts as a mediator between an individual's thoughts and actions (Dickerson, 2019). It is one of the most important variables that affect behavior (Anastasiadou and Karakos, 2011). It represents the emotional side of CT abilities (Avcu & Ayverdi, 2020) and has effects on some skills such as analysis, solving simple problems, debugging, and computer working principles (Durak & Yilmaz, 2019).

Self-efficacy is an important variable in predicting CT (Dickerson, 2019), as it affects CT competencies (Tsai et al., 2019), and develops CTskills (Shell et al., 2014; Webb and Rosson, 2013). It enhances the continuous use of digital tools, dedication, duty or responsibility, cooperative work, and pleasure when using digital or virtual tools (Pellas and Kazanidis, 2014), reduces computational anxiety (Durndell & Haag, 2002), increases situational interest in the learning process and develops an academic self-concept. (Pellas & Kazanidis, 2014), and maintains motivation and improves skill development (Chunk, 1991).

Computational Self-Efficacy is defined as an individual's judgments about using a computer (Marakas et al., 1998; Compeau and Higgins, 1995). It also refers to the effort expended by the individual in performing and practicing CTand solving computer problems based on programming, as well as their attitude toward CT skills (Trevelyan, 2011; Yagci, 2016). An individual with high computational self-efficacy effectively uses a variety of computer equipment and systems and seeks to identify their strengths and weaknesses (Dumbauld et al., 2014). On the other hand, a person with low computational self-efficacy exerts less effort and perseverance regarding the task and thus fails to complete it (Nordén et al., 2017).

Studies related to teacher computational self-efficacy indicate that teachers have a low level of competence in using computational skills related to media (Sarfo et al., 2017) and a low level of competence in using multimedia programs and database application programs (Sarfo et al., 2016). Teachers also tend to have a moderate level of self-efficacy in using computers (Kumari, 2021) and are often reluctant to use technology in the classroom (Singh et al. 2018). Furthermore, there is a moderate relationship between CTskills and self-efficacy (Durak & Yilmaz; 2019; Bocconi et al., 2016).

Other studies indicated that experienced teachers have a higher level of self-efficacy in teaching computer science compared to less experienced teachers (Schwarzhaupt et al., 2021). Teachers also tend to have good perceptions of their self-efficacy in using computers (Turel, 2014), and their self-efficacy is positively linked to a high level of educational technology use (Buchanan et al., 2013).

Teacher self-efficacy is positively related to technology integration in education and increases their intention to use technology (Afari et al., 2023). It is related to general and specific computer knowledge (Gudek, 2020), attitudes toward using digital technology (Gudek, 2019), motivation and building competencies (Zee & Koomen, 2016; Erik et al., 2011; John et al., 2001), and reduced computer anxiety, as well as a positive attitude toward the Internet and spending more time using it (Durndell and Haag, 2002).

Additionally, teachers' computational self-efficacy is related to computer information literacy (CIL), independent learning in information and communications technology (Hatlevik & Hatlevik, 2018), computer programming, and CT skills (Avcu & Ayverdi, 2020; Türker & Pala, 2020). It is also associated with the use of digital or virtual technologies in education (Santos, 2021), and is related to information skills and academic performance (Cardoso Espinosa et al., 2021). Therefore, teachers need to have an excessive degree of self-efficacy in CT(Krejčová et al., 2019), as a positive computational self-efficacy allows them to continue performing well (Cardoso Espinosa et al., 2021), enhances their ability to manage the educational environment and build students' self-efficacy (Yıldızlı, 2019), and affects their teaching approach in the classroom (Pajares, 1992).

The importance of teachers' computational self-efficacy is further highlighted by the fact that it represents a strong indicator of the manner they form their pedagogical practices to enhance students' motivation to study and learn (Erik et al., 2011). It is relevant to education and activities in which students' CT abilties are addressed and developed (Vennila et al., 1998). This is because a teacher's computational skills alone are not the only factor determining their performance. Their CT self-efficacy must exist alongside these skills to perform effectively in the classroom (Schunk, 1991). Overall, computational self-efficacy is an crucial construct that have to be addressed, as teachers need to combine technology into teaching, modify their teaching method, and reconsider their beliefs and attitudes toward using CT skills (Nelson & Hawk, 2021; Tondeur et al., 2017; Dickerson, 2019).

Attitudes Toward Using Computational Thinking Skills

Attitude is defined as the set of perceptions an individual has toward a topic, whether it is acceptance or rejection (Alnoursi, 2013). It represents a tendency to accept or reject a specific topic (Oskamp & Schultz, 2005). Attitude is a set of positive, negative, and neutral feelings that can effectively enhance or hinder the learning process (Ahmed, 2015). It is one of the factors influencing teachers' behavior, feelings, and beliefs, and guiding their behavior in the educational process (Yusuf & Balogun, 2011). Attitudes play an crucial role in a teacher's choice and decision to practice appropriate teaching behaviors to increase learner effectiveness in the educational situation (Abudu & Gbadamosi, 2014).

Studies have revealed that teachers' positive attitudes play an effective role in the educational procedure. They can enhance the use of technological innovations and their applications in education, and affect confidence in directing learners' interest toward using technology (Vongkulluksn et al., 2018; Mai, 2015; Rana, 2012).

According to Brennan & Resnick (2012) and Kong (2018), attitudes strongly affect the acquisition of CT skills, and constitute the affective aspect of CT. Positive attitudes can enhance the individual's self-confidence to accomplish complex tasks, show tolerance for situations of uncertainty, and persevere and persist in solving difficult and open-ended troubles, arriving at a solution through collaborative work, and being aware of private strengths and weaknesses while working with others (Barr & Stephenson, 2011).

Studies have proven the critical role of affective factors "attitudes" in teaching CT skills (Yildiz-Durak & Saritepeci, 2018). Attitudes have been found to significantly predict CT skills (Richado et al., 2023; Roman-Gonzalez et al. al., 2016). Therefore, it is important to strengthen individuals' positive attitudes toward CT (Gulbahar et al., 2019). Roman-Gonzalez et al. (2018) indicated that non-cognitive factors (affective factors) explain 24% of CT skills.

According to Laime-Choque et al., (2022), there is a regular level of attitudes toward using CT , and attitudes predict its skills and play a mediating role between programming experience and CT skills (Sun et al., 2022). Mahajan (2016) found that only about 25% of teachers have a positive attitude toward using technology in teaching and that teachers' attitudes toward CT are often low, though they can improve with effective interventions (Saxena and Chiu, 2022). Teachers have also been found to have little interest in applying CT skills in teaching and learning (Senin & Nasri, 2019).

In general, CT competencies and skills can be enhanced via the improvement of fundamental attitudinal dimensions, including confidence in handling complexity, interest, persistence in operating with complicated problems, the capability to work and communicate with others to gain a common goal, tolerance for ambiguity, and the capacity to cope with open issues or problems. These positive attitudes can help foster key CT concepts and skills, such as formulating troubles and problems, organizing and analyzing data and information logically, representing it via models, identifying possible solutions, and generalizing the hassle-fixing technique to an extensive range of problems..

4. Methodology

Research design

The study utilized the descriptive correlational approach, because it focuses on determining the levels of both self-efficacy in CT and the attitude toward using CT skills among teachers, in addition to determining the relationship between CT self-efficacy and the attitude toward using CT skills among teachers.

Sampling

The sample consisted of (320) teachers from the Eastern Province of Saudi Arabia. Their ages ranged between (30-45) years with an average age of (40.45) years and a standard deviation of (10.26) years. The skewness coefficient for the age variable was (0.534) indicating a moderate skewed distribution. This suggests that the distribution of the sample members across the study variables was balanced, without any extreme skewness or clustering.

Data Collection Tools

Computational Thinking Self-Efficacy Scale

The scale aims to measure teachers' CT self-efficacy, which is a complex skill that can be difficult to observe directly. Following the guidance of DeVellis (2003), A comprehensive literature review related to CT and its basic skills was conducted, including works by Pewkam & Chamrat (2022), de Jesusi & Silveira (2022), Aho (2012), Korkmaz et al. (2017), García-Peñalvo (2016), Bocconi et al. (2016), Grover & Pea (2013), and Wing (2008), and studies that addressed self-efficacy such as (Cardoso et al., 2021; Kukul and Karatas, 2019; Dickerson, 2019; Tsai et al., 2019; Nordén et al., 2017; Yang & Cheng, 2009; Cassidy & Eachus, 2002). Accordingly, 45 items were identified, and distributed across nine dimensions: Algorithms, Problem Decomposition, Abstraction, Parallelization, Data Collection, Incremental and Iterative, Control Flow, Testing and Debugging, and Questioning.

The items have been reviewed by a panel of six specialists in teaching CT , measurement, and evaluation to decide the extent to which each item is related to the main dimension to which it belongs, evaluate the accuracy of the linguistic formulation of the items, and provide recommendations to add, delete, or modify any of the items as they deemed appropriate for the scale. According to their comments, inappropriate items were removed and modifications were made to some of the items, so that the last form of the scale includes (35) items distributed across nine dimensions of CT , and formulated as a five-point Likert scale (1 = "strongly disagree", 2 = "Disagree", 3 = "Neutral", 4 = "Agree", 5 = " strongly agree"). The total possible score on the scale ranges from 175 to 35, with a higher score indicating a higher CT self-efficacy.

The scale's reliability was verified using Cronbach's alpha coefficient on a sample of (53) teachers in Saudi Arabia. The dimensions of the scale have been as follows: Algorithms dimension (4 items), Abstraction dimension (4 items), Problem Decomposition dimension (4 items), Parallelization dimension (4 items), Data Collection dimension (4 items), Control Flow dimension (4 items), Incremental and Iterative dimension (4 items), Testing and Debugging dimension (4 items), Questioning dimension (3 items). The alpha values for the dimensions were 0.81, 0.79, 0.83, 0.85, 0.74, 0.76, 0.82, 0.79, and 0.81 respectively. The general Cronbach's α coefficient value of the CT Self-Efficacy Scale (35 items) was calculated as (0.793).

The scale's validity was also calculated using the internal consistency analysis, by calculating the correlation coefficient between the scale's dimensions, which ranged between (0.58 - 0.76) and is statistically significant at (0.01). Additionally, the correlation coefficients between the dimensions and the scale as a whole ranged between (0.63 – 0.87) and were significant at (0.01). Generally, the scale and its dimensions showed a high level of reliability, validity, and internal consistency.

Attitudes Toward Using Computational Thinking Skills Scale

The scale was to measure teachers' attitudes toward using CT skills. The scale items were developed after reviewing the literature related to attitudes toward using CT such as (Yildiz-Durak & Saritepeci, 2018; Vongkulluksn et al., 2018; Avcu & Ayverdi, 2020; Mai, 2015; Rana, 2012; Brennan & Resnick, 2012). Initially, 25 items were identified and distributed across five dimensions: Interest, Meaningfulness, Impact, Confidence in CT skills, and Professional life.

The items have been reviewed by a panel ofsix specialists in teaching CT , measurement, and evaluation. According to their comments, inappropriate items were removed and modifications were made to some of the items. Therefore, the last form of the scale includes (20) items distributed across five dimensions and formulated as a five-point Likert scale (1 = “strongly disagree”, 2 = “disagree”, 3 = “neutral”, 4 = “agree”, 5 = “strongly agree”). The total possible score on the scale ranges from 20 to 100, with a higher score indicating a higher attitude toward using CT skills. The scale’s reliability was verified using Cronbach’s alpha coefficient on a sample of (53) teachers in Saudi Arabia. The dimensions of the scale were as follows: Interest dimension (6 items), Meaningfulness dimension (3 items), Impact dimension (4 items), Confidence in CT skills dimension (3 items,), and Professional life dimension (4 items). The alpha values for the dimensions were 0.799, 0.818, 0.826, 0.787, and 0.758 respectively.

The general Cronbach’s α coefficient value of the Scale (20 items) was calculated as .788. The scale's validity was also calculated using the internal consistency analysis, by calculating the correlation coefficient between the scale's dimensions, which ranged between (0.597 - 0.798) and is statistically significant at the level of (0.01). Additionally, the correlation coefficients between the dimensions and the scale as a whole ranged between (0.599 – 0.821) and were statistically significant at (0.01). Generally, the scale and its dimensions showed a high level of reliability, validity, and internal consistency.

5. Results and Discussion

Q1: What is the level of teachers’ Computational Thinking Self-Efficacy?

To answer the first question, means, standard deviations, and t-test were used to compare the means of the sample’s scores on the computational thinking self-efficacy scale and the hypothetical average. The relative average for each dimension of the scale was also calculated (mean ÷ number of scale items). In light of the relative average, three levels were determined (low, medium, high), by dividing the range of scores on the item (5 - 1 = 4) into equal segments, which are the low level from 1 to 2.32, the medium level from 2.33 to 3.66, and the high level from 3.67 to 5. Table 1 shows these results.:

Table 1. t-test to compare the mean of the sample’s scores on the Computational Thinking Self-Efficacy scale and the hypothetical average (N = 320)

Dimension	Mean	hypothetical average	Std. Deviation	t- test	Sign.	Relative average	The Level
Algorithms dimension	11.14	13.00	3.05	10.92	0.001	2.79	medium
Abstraction dimension	10.99	12.5	3.56	7.55	0.001	2.75	medium
Problem Decomposition dimension	10.94	12.00	3.67	5.16	0.001	2.74	medium
Parallelization dimension	11.11	13.00	3.03	11.16	0.001	2.78	medium
Data Collection dimension	11.28	13.00	2.91	10.57	0.001	2.82	medium
Control Flow dimension	11.31	12.5	2.95	7.19	0.001	2.83	medium
Incremental and Iterative dimension	11.24	12.5	2.90	7.75	0.001	2.81	medium
Testing and Debugging Iterative dimension	10.96	12.00	3.56	5.22	0.001	2.74	medium
Questioning dimension	10.30	11.5	2.12	10.17	0.001	3.43	medium
Computational Thinking Self-Efficacy Scale	99.28	104.00	23.62	3.574	0.001	2.84	medium

Table (1) indicates that there are statistically significant differences at the significance level of (0.001) between the means of the sample's scores on the Dimensions of CT Self-Efficacy scale and the hypothetical average in favour of the hypothetical average. This means that the teachers have a medium level of CT Self-Efficacy.

This result is consistent with several preceding studies. Sarfo et al. (2017) found a low level of teacher self-efficacy in using computer skills related to media, while Sarfo et al. (2016) reported a low level of self-efficacy among teachers in using multimedia programs and database application programs. Kumari (2021) found a medium level of self-efficacy among teachers in using computers, and Singh et al. (2018) discovered that teachers have low self-efficacy, which makes them reluctant to use technology tools in learning environments.

Furthermore, this result confirms the findings of Özmen and Altun (2014), which attributed teachers' failure in programming to low self-efficacy. They also noted that high perceptions of teacher self-efficacy affect their performance in CT skills positively.

This result further confirms the findings of previous studies, which have highlighted the connection between CT self-efficacy and the practice of CT skills. Talsma et al. (2018) pointed out that difficulty in learning and practicing CT skills may be due to a decrease in self-efficacy, and that self-efficacy affects the practice of these skills (Malone & Lepper, 2021; Murnieks et al., 2020; Kong et al., 2018; Yildiz-Durak, 2018; Yang & Cheng, 2009).

The medium level of CT self-efficacy can be attributed to the teachers' lack of sufficient experience with CT abilities and skills (Schwarzhaupt et al., 2021) and the absence of strong perceptions of self-efficacy in using unique CT abilities and skills, such as data collection, parallelization; representation, and analysis; incremental and iterative; control flow; testing and debugging; and questioning (Cardoso Espinosa et al., 2021; Turel, 2014). The low computational self-efficacy may lead the teachers to exert less effort in performing teaching tasks and fail to complete them, ultimately affecting their practice of CT skills (Malone & Lepper, 2021; Murnieks et al., 2020; Özmen & Altun, 2014; Nordén et al., 2017; Erik et al., 2011).

This result can be explained by the teachers' lack of prior information about CT, their perception of these skills as complex and difficult to learn (Durak & Yilmaz, 2019), and their inability to effectively link their knowledge and skills with self-efficacy to achieve better performance (Bandura, 1993). Additionally, the teachers may have limited exposure to sources of CT self-efficacy, such as observing other competent teachers using technological resources efficiently and possessing strong CT skills, as well as a lack of engagement in learning groups and exchange of experiences with more proficient teachers. The educational environment may also lack the social support necessary to motivate teachers to practice CT (Santos et al., 2021; Dickerson, 2019).

To address this issue, the study suggests the significance of developing education programs for teachers to promote their CT skills and CT self-efficacy and provide opportunities to practice various educational activities that enhance the use of CT skills and the performance of teaching-related tasks with ease.

Q2: What is the level of teachers' Attitudes toward using Computational Thinking Skills Scale?

To answer the second question, means, standard deviations, and t-test were used to compare the means of the sample's scores on the Attitudes toward Using Computational Thinking Skills Scale and the hypothetical average. The relative average was also calculated for each dimension of the scale, and in light of the relative average, three levels were determined (low, medium, high), Table 2 shows these results.

Table 2. t-test to compare the mean of the sample's scores on the Attitudes Toward Using Computational Thinking Skills Scale and the hypothetical average (N = 320)

Dimension	Mean	Hypothetical average	Std. Deviation	t- test	Sig.	Relative average	The level
Interest dimension	15.95	19.5	4.89	12.977	0.001	2.16	medium
Meaningfulness dimension	10.23	11.5	2.06	10.98	0.001	3.41	medium
Impact dimension	11.23	12.00	3.32	4.13	0.001	2.81	medium
Confidence in CT skills dimension	10.18	11.5	2.04	11.59	0.001	3.39	medium
Professional life dimension	11.02	12.5	3.64	7.27	0.001	2.76	medium
Attitudes Toward Use of Computational Thinking Skills Scale	58.62	65.00	10.21	11.18	0.001	2.93	medium

Table (2) indicates that there are statistically significant differences at the significance level of (0.001) between the means of the sample's scores on the Dimensions of Attitudes Toward Using CT Skills Scale and the hypothetical average in favour of the hypothetical average. This means that the teachers have a medium level of attitudes toward using CT Skills.

This result is steady with Laime-Choque et al., (2022), who found a moderate level of attitudes toward using CT, and Mahajan (2016), who reported that only about 25% of teachers have a positive attitude toward using technology in teaching. Additionally, Saxena and Chiu (2022) observed that teachers' attitudes toward CT are low. Moreover, Senin & Nasri (2019) found that the teacher has a small amount of interest in applying CT skills in teaching and learning.

The medium attitudes toward CT can be attributed to the teachers' lack of knowledge about CT and how to apply it to resolve complicated problems (Barr and Stephenson 2011). Teacher preparation programs do not effectively integrate CT skills and concepts, which fails to influence teachers' attitudes and understanding (Yadav et al., 2014; Morreale and Joiner, 2011).

Therefore there is no strengthening of the correlation between attitudes toward using these skills through teacher preparation programs (Perdana et.al., 2021; Korkmaz & Xuemei, 2019; Richardo & Martyanti, 2019).

This result highlights the importance of implementing effective interventions in teacher preparation programs. Studies have indicated a low percentage of teachers who have a positive attitude toward using technology in their pedagogical practices (Saxena & Chiu, 2022). Additionally, research has indicated that teachers' attitudes toward CT are relatively low, but these attitudes can be improved through the implementation of targeted interventions (Mahajan, 2016).

This result also emphasized the importance of enhancing teacher's positive attitudes toward using CT skills, studies have shown that teachers' attitudes play a crucial role in the educational process and the teaching of CT skills (Yildiz-Durak & Saritepeci, 2018).

Teachers' attitudes can activate the use of these skills in education and affect their confidence in directing students' interest toward using CT (Vongkulluksn et al., 2018; Mai, 2015; Rana, 2012). Additionally, teachers' attitudes significantly predict their CT skills (Richado et al., 2023; Avcu & Ayverdi, 2020; Roman-Gonzalez et al., 2016). Cultivating positive attitudes toward CT can also enhance teachers' ability to complete complex tasks, persevere, and persist in solving open-ended and difficult troubles or problems (Barr & Stephenson, 2011).

Q3: : Is there a statistically significant relationship between teachers' computational thinking self-

efficacy and their attitudes toward using computational thinking skills?

To answer the third question, Pearson's correlation coefficient was used to find the relationship between Computational Thinking Self-Efficacy, and Attitudes toward using Computational Thinking Skills and Table 3 shows these results.

Table 3. Correlation coefficients between Computational Thinking Self-Efficacy, and Attitudes toward using Computational Thinking Skills (N = 320)

Variables		Attitudes Toward Using Computational Thinking Skills Scale					
		Interest dimension	Meaningfulness dimension	Impact dimension	Confidence in CT skills dimension	Professional life dimension	Total
Computational Thinking Self-Efficacy Scale	Algorithms dimension	*0.479***	*0.668***	*0.886***	*0.656***	*0.458***	*0.735***
	Abstraction dimension	*0.339***	*0.613***	*0.952***	*0.605***	*0.464***	*0.743***
	Problem Decomposition dimension	*0.319***	*0.326***	*0.489***	*0.283***	*0.989***	*0.673***
	Parallelization dimension	*0.286***	*0.668*	*0.885***	*0.656***	*0.456***	*0.734***
	Data Collection dimension	*0.316***	*0.662***	*0.861***	*0.651***	*0.440*8*	*0.715***
	Control Flow dimension	*0.279***	*0.698***	*0.836***	*0.688***	*0.404***	*0.709***
	Incremental and Iterative dimension	*0.276***	*0.700***	*0.830***	*0.692***	*0.396***	*0.702***
	Testing and Debugging Iterative dimension	*0.379***	*0.330***	*0.488***	*0.288***	*0.982***	*0.670***
	Questioning dimension	*0.279***	*0.984***	*0.600***	*0.969***	*0.316***	*0.679***
	Total	*0.316***	*0.613***	*0.952***	*0.605***	*0.464***	*0.743***

** The Pearson's Correlation coefficients are statistically significant at 0.01.

Table (3) shows a positive statistically significant relationship between CT self-efficacy and attitudes toward using CT skills. Specifically, the correlation ranged from 2.76 to 0.989, and these relationships were statistically significant at the level of 0.01.

This indicates that as teachers' CT self-efficacy increases, their attitudes toward using CT skills also become more positive. The strength of the correlation, ranging from medium (0.276) to very strong (0.989), suggests that these two factors are closely linked and reinforce each other. This result is consistent with Pellas and Kazanidis (2014), who found that self-efficacy enhances the continuous use of digital tools, commitment, responsibility, and satisfaction when using these tools. Additionally, Durndell & Haag (2002) found that self-efficacy reduces computer anxiety, that's consistent with the findings that self-efficacy increases situational interest in the learning process, as reported by Pellas and Kazanidis (2014).

This aligns with Zee & Koomen (2016); Erik et al., (2011); and John et al., (2001), who demonstrated a positive relationship between self-efficacy, and motivation. Furthermore, Durndell and Haag (2002) found a statistically significant relationship between computational self-efficacy and positive attitude toward the Internet, while Gudek (2019, 2020) reported a relationship between computational self-efficacy and attitudes toward using digital tools and technology.

The existing literature also supports the relationship between self-efficacy and diverse digital capabilities and skills and competencies. Hatlevik and Hatlevik (2018) found a relationship between self-efficacy in information and communications technology (ICT) and Computer information knowledge. Türker and Pala (2020) reported a relationship between self-efficacy in programming and CT capabilities and skills. Additionally, Santos (2021) discovered a relationship between computer self-efficacy and the use of digital technologies in education, and Cardoso Espinosa et al. (2021) demonstrated a relationship between computational self-efficacy levels, information skills, and academic performance.

The results of this study also support a growing body of research that has demonstrated that teachers' attitudes are key variables in enhancing the use of CT skills (Richado et al., 2023; Cutumisu et al., 2021). Additionally, Hava and Koyunlu Ünlü (2021) and Cutumisu et al. (2021) indicated a statistically extensive relationship between teachers' attitudes toward CT and self-efficacy in using these skills. Moreover, teachers' attitudes toward CT can predict their CT skills, and play a mediating role between their experience and CT abilities (Sun et al., 2022).

This is consistent with the results of Türker and Pala (2020) and Durak and Yilmaz (2019), which showed that the teacher's CT self-efficacy affects their use of CT skills, such as abstraction; data collection, parallelization; incremental and iterative; and questioning. Furthermore, the results align with Afari et al., (2023), who found that teachers' CT self-efficacy will increase their intention to use technology, Zee & Koomen (2016); Erik et al., (2011); and John et al., (2001), which demonstrated a positive relationship between teacher's self-efficacy, learner' motivation, and the development of student competencies. Collectively, these studies support a strong relationship between teachers' CT self-efficacy and their attitudes toward using CT skills in the classroom.

6. Synopsis of the Main Research Outcomes

The study found that teachers had an average level of computational thinking self-efficacy (Algorithms dimension, Abstraction dimension, Problem Decomposition dimension, Parallelization dimension, Data Collection dimension, Control Flow dimension, Incremental and Iterative dimension, Testing and Debugging Iterative dimension, and Questioning dimension). The study also found that there is an average level of attitudes towards using computational thinking (Interest dimension, Meaningfulness dimension, Impact dimension, Confidence in CT skills dimension, and Professional life dimension). Finally, a positive relationship was found between self-efficacy in computational thinking and attitudes toward using computational thinking skills.

7. Conclusions

The current study concluded that there is a medium level of teachers' CT self-efficacy and attitudes toward using CT skills. In addition, there is a statistically significant relationship between teachers' CT self-efficacy and attitudes toward using CT skills. The results emphasize the importance of the affective or non-cognitive aspects (attitudes and self-efficacy) of CT. Future studies should focus on enhancing the affective aspects of the teachers, particularly their self-efficacy and attitudes toward using CT skills, as these factors have a significant effect on their performance and practice of CT skills. Teacher preparation programs should be supported by educational interventions aimed at strengthening both self-efficacy and positive attitudes toward using CT skills. Moreover, the results underscore the importance of having communities of practice that assist teachers in expanding their professional networks and accessing more professional development resources, which can further develop self-efficacy and positive attitudes toward using CT skills..

8. Limitations, Implications, and Further Directions of Research

Avcu & Ayverdi (2020) argued that relying only on a Likert-style measurement tool to assess CT self-efficacy and attitudes toward using CT may not have provided a comprehensive evaluation, so more assessment tools should have been utilized. In addition, the use of self-report measures is prone to measurement error, as teachers may have over- or underestimated their CT self-efficacy and attitudes. The descriptive, correlational approach cannot establish a causal relationship between CT self-efficacy and attitudes toward using CT.

Moreover, previous research (Sarfo et al., 2016) has indicated that variables such as teachers' experience, training courses, educational qualifications, and gender can influence their self-efficacy and attitudes toward CT. Despite this, the study did not investigate the impact of these variables.

Teacher preparation programs should be directed towards inculcating computational thinking skills, and should support computational thinking self-efficacy and teachers' tendencies and attitudes towards computational thinking, as they constitute the emotional dimension of computational thinking such as self-confidence to accomplish complex tasks, showing tolerance, persistence and insistence to solve difficult and open-ended problems, and cooperation with others. Computational thinking self-efficacy and attitudes towards using computational thinking significantly predict teachers' computational thinking skills, , and have an impact on students' performance..

Based on the results of the current study, the researcher suggests the following:

1. The need to develop educational interventions that enhance teachers’ CT self-efficacy and positive attitudes toward using CT.
2. Incorporating non-cognitive aspects related to CT into teacher preparation programs.
3. Investigating the most critical affective variables that predict teachers’ CT skills.
4. Examining the mediating roles of teacher-associated variables that affect teachers’ CT self-efficacy and attitudes toward using CT.
5. Study of training needs for the use of computational thinking skills and their relationship to self-efficacy among teachers.
6. Building a proposed vision for developing computational thinking skills among teachers in light of the requirements of the Fourth Industrial Revolution

Conflict of Interests

The author acknowledges and declares that there is no potential conflict of interest about the authorship and publication of the current study.

The data availability statement

Data cannot be shared openly but are available on request from the author.

Institutional Review Board Statement

The Ethical Committee of the College Education, Imam Abdulrahman Bin Faisal University, Kingdom of Saudi Arabia has granted approval for this study (IRB-2024-15-428).

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