



Computational thinking: early childhood teachers' and prospective teachers' preconceptions and self-efficacy

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Abstract

Computational thinking (CT) is considered a group of problem-solving skills that the next generations are expected to possess. The most efficient way to make them acquire these skills is to incorporate CT into K-12 education. To this end, various education programs have been designed to improve teachers' and prospective teachers' competence in CT. Such programs designing educational experiences based on teachers' and prospective teachers' preexisting opinions and self-efficacy perceptions about CT could achieve better results. Although the acquisition of CT skills has been suggested to start early on, these beliefs of early childhood teachers and prospective teachers have been underexplored. Therefore, this exploratory study aims to examine early childhood teachers' and prospective teachers' preconceptions and self-efficacy about CT. The study was conducted with 63 teachers and 78 prospective teachers in Turkey. Data were collected via an online survey in the spring of the 2020–2021 academic year. The preconceptions were assessed using a structured questionnaire, while the CT self-efficacy was measured with the *Computational Thinking Scale*. The findings showed similarities between teachers and prospective teachers in the preconceptions of CT. Both of them most strongly associated CT with logical thinking, problem-solving, using algorithms, coding/programming, doing mathematics, using technology in teaching, and using computers. Yet, teachers reported stronger associations between CT and logical thinking, using algorithms, and coding/programming. Furthermore, teachers' self-efficacy perceptions in CT were significantly higher. The study findings provide some needed information to design professional development programs aiming to enhance CT practices in early education settings.

Keywords Computational thinking · Preconception · Self-efficacy perception · Early childhood teachers · Early childhood prospective teachers

1 Introduction

The concept of computational thinking (CT) recognized as *algorithmic thinking* in the 1950 and 1960s has been considered within the scope of computer science (CS) education for a long time (Denning, 2009). Since Wing's (2006) argument on the applicability of CT to disciplinary fields other than CS, researchers and educators have begun a debate on the value of being competent in CT which means thinking like computer scientists (Bocconi et al., 2016; Denning, 2017; Grover & Pea, 2013; Román-González et al., 2018). The next generations are expected to possess this specific thought process (Grover & Pea, 2018; Mishra et al., 2013; National Research Council [NRC], 2010; Voogt et al., 2015; Wing, 2006) so that they could acquire 21st-century skills (Angeli & Giannakos, 2020; Bocconi et al., 2016), benefit from the rapid changes in technology (Sykora, 2021), solve problems both with and without computers (Grover & Pea, 2018; Sykora, 2021; Wing, 2006), and be both users and producers of technological tools (Aho, 2012; Angeli et al., 2016). Furthermore, it is argued that acquiring skills such as debugging, decomposition, pattern recognition, abstraction, iteration, generalization, and algorithmic thinking included in CT (Shute et al., 2017; Wing, 2011) could expand their problem-solving capacity (International Society for Technology in Education [ISTE], 2021a; Sykora 2021) and make them succeed in various disciplines and professions (Wing, 2011). The most effective way to facilitate the acquisition of these skills by children is to introduce CT in K-12 education (Angeli et al., 2016; Boccani et al., 2016; Grover & Pea 2013; Hsu et al., 2018; Lee et al., 2020; Lu & Fletcher, 2009; Mannilla et al., 2014; Mishra et al., 2013; Qualls & Sherrell, 2010; Voogt et al., 2015; Wing, 2008; Yadav et al., 2011).

Being successful in embedding CT into the school curriculum depends on the extent to which teachers in all subject areas and grade levels have CT competence (ISTE, 2021b) that involves content knowledge and pedagogical content knowledge in CT (Cabrera, 2019; Rich et al., 2019; Shute et al., 2017). Thus, teachers' professional development in CT needs to be supported both by pre-service and in-service training programs (Barr & Stephenson, 2011; Gadanidis et al., 2017; Hunsaker & West, 2020; Simmonds et al., 2019; Yadav et al., 2016, 2017; Wing, 2006). The design of the professional development and education programs, resources, and policies based on teachers' and prospective teachers' preconceptions of the concepts and the competencies of CT (Cabrera, 2019; Denning, 2017; Rich et al., 2019), as well as their CT self-efficacy (Rich, Larsen, et al., 2021) could enhance their engagement in learning experiences offered in such programs, valuation of CT in student learning, and effectiveness in integrating CT into their practice (Rich, Larsen, et al., 2021; Rich, Mason, et al., 2021).

The number of studies focusing on teachers' and prospective teachers' preconceptions of and competence in CT has been increasing in recent years (e.g., Bower et al., 2017; Rich, Mason, et al., 2021; Uzumcu & Bay 2021; Yadav et al., 2016; Yadav et al., 2017; Zha et al., 2020). Although it is recommended to support children's CT processes starting from kindergarten, early childhood teachers' and prospective teachers' CT-related beliefs have been underexplored (Bers et al., 2013; Haseski & Ilic, 2019; Hunsaker & West, 2020; Hsu et al., 2018; Kalogiannakis & Papadakis, 2017; Kotsopoulos et al., 2021; Shute et al., 2017). Research on young children has

shown that they need explicit scaffolding to think computationally (Angeli & Valanides, 2020; Georgiou & Angeli, 2021; Newhouse et al., 2017), however, the majority of early childhood teachers lack knowledge and confidence about CT (Kalogiannakis & Papadakis, 2017; Kotsopoulos et al., 2021; Murcia et al., 2018). Considering the needs prior research points out, this study aims to investigate how early childhood teachers and prospective teachers conceive of CT and the extent that they perceive themselves competent in thinking computationally. This study contributes to the body of knowledge by describing a conveniently sampled group of early childhood teachers' and prospective teachers' current beliefs about CT which could provide some needed information to design professional development programs aiming to enhance CT practices in early education settings. Furthermore, comparing the preconceptions and the CT self-efficacy of early childhood teachers with those of prospective teachers, this study informs researchers and teacher educators about the unique needs of the two groups which should be considered while designing specialized education programs for each of them. Thus, we present our findings and discuss their implications for teacher professional development in CT.

1.1 Computational thinking

There are many different views on the definition of and the skills involved in CT (Grover & Pea, 2013). Wing (2011), a mostly cited scholar, defined CT as “the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent” (p. 20). Besides problem-solving (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019; Grover & Pea, 2018; Kazimoglu et al., 2012; Shute et al., 2017; Wing, 2017), other widely-used definitions of CT involves skills of designing, analytical thinking, abstraction, scientific thinking (Shute et al., 2017; Wing, 2017), debugging (Aho, 2012; Angeli et al., 2016; Grover & Pea, 2018; Hemmendinger, 2010; Kazimoglu et al., 2012; Shute et al., 2017), algorithmic thinking (Kazimoglu et al., 2012; García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019; Shute et al., 2017), numerical thinking and calculation (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019), pattern recognition, generalization (Shute et al., 2017), cooperativity and creativity (Grover & Pea, 2018).

We have been all living a life greatly affected by CT and individuals who can think computationally are needed all over the world (Barr & Stephenson, 2011; Denning, 2009; Kotsopoulos et al., 2017). Therefore, in many countries, such as Estonia, Israel, Finland, and the United Kingdom, CT has become a part of school curricula starting from kindergarten (Angeli & Giannakos, 2020; Hsu et al., 2018). Although CT has not yet been integrated into the early childhood education program in Turkey, problem-solving, computational thinking, and coding have been determined as goals of primary and secondary education (Bocconi et al., 2016; Ministry of National Education [MoNE], 2018). However, teacher educators and researchers argue that CT is a competence that should be supported early on (Barr & Stephenson, 2011; Buitrago Flórez et al., 2017; Gibson, 2012; Yadav et al., 2014). Early exposure to CT could be critical in establishing a solid foundation for the acquisition of further skills (Barr & Stephenson, 2011; Buitrago Flórez et al., 2017; Gibson, 2012; Grover & Pea, 2018;

Lu & Fletcher, 2009; Wing, 2008), as well as in determining individuals' motivation and interest in it from a young age (Yadav et al., 2014).

By embedding CT into classroom practices with an age-appropriate pedagogies and modeling the use of CT-related skills and CT process, teachers can provide support for children in using this thought process to solve problems encountered both in real life and in key content areas (ISTE, 2021b; NRC, 2010). To be able to promote CT in education settings, teachers must first understand the concept of CT and have CT competence (Barr & Stephenson, 2011; Orvalho, 2017; Yadav et al., 2014). A variety of factors could influence teachers' understanding of and competence in CT. Of these factors, this study focuses on teachers' and prospective teachers' preconceptions of and self-efficacy perceptions in CT. Fang (1996) defines preconceptions, attitudes, values, and self-efficacy as the factors that play a role in the construction of beliefs. Thus, in this study, we examine two of these factors that could influence teachers' beliefs about CT.

1.2 Teachers' and prospective teachers' preconceptions of computational thinking

Teachers' and prospective teachers' opinions about CT formed beforehand could influence their new learnings and even practices in CT (Cabrera, 2019). Thus, researchers and teacher educators should explore their preconceptions of CT before forming professional development and education programs and aligning school curricula with the skills involved in CT (Cabrera, 2019; Rich et al., 2019; Yadav et al., 2018). This exploration enables researchers and teacher educators to reveal if teachers and prospective teachers have any misconceptions about CT since misconceptions can negatively affect teachers' and prospective teachers' ability to develop their knowledge and skills about CT and effectively incorporate CT into their classroom practices (Cabrera, 2019). Some teachers could have firmly-held preconceptions (Fang, 1996), and maintain their preconceptions identified as misconceptions even after attending a CT training program (Ung et al., 2022). This evidence validates the importance of revealing teachers' preexisting opinions about CT and developing appropriate training programs to accomplish the desired improvements in them.

Teachers' and prospective teachers' preconceptions of CT were mostly examined through their written responses to open-ended questions, such as "What do you think computational thinking is?" (Bower & Falkner, 2015; Corradini et al., 2017; Garvin et al., 2019; Hunsaker & West, 2020; Lamprou & Repenning, 2018; Lloyd & Chandra, 2020; Looi et al., 2020; Morreale et al., 2012; Mouza et al., 2017; Umutlu, 2021; Ung et al., 2022; Walton et al., 2020; Yadav et al., 2018), while in only one study, in-depth interviews with primary school teachers were utilized (Rich et al., 2019) and in another study, a predetermined list of skills was given to examine teachers' preexisting opinions about the skills included in CT (Sands et al., 2018). In a recent study including 369 primary and secondary school teachers in Malaysia, 90.80% of the participants reported no knowledge of CT (Ung et al., 2022). When asked to define CT, most teachers stated problem-solving (Bower et al., 2017; Garvin et al., 2019; Morreale et al., 2012; Rich et al., 2019; Sands et al., 2018; Walton et al., 2020; Yadav et al., 2018), using algorithms (Bower et al., 2017; Corradini et al., 2017; Garvin et

al., 2019; Rich et al., 2019; Sands et al., 2018; Walton et al., 2020; Yadav et al., 2018), logical thinking (Bower et al., 2017; Corradini et al., 2017; Sands et al., 2018; Yadav et al., 2018), and coding/programming (Bower et al., 2017; Garvin et al., 2019; Sands et al., 2018; Ung et al., 2022; Yadav et al., 2018). With a relatively lower frequency, teachers also associated CT with abstraction and decomposition (Bower et al., 2017; Garvin et al., 2019; Yadav et al., 2018), data collection (Bower et al., 2017; Walton et al., 2020; Yadav et al., 2018), data analysis and representation (Walton et al., 2020; Yadav et al., 2018), mathematics (Garvin et al., 2019; Sands et al., 2018; Ung et al., 2022), using computer/technology (Corradini et al., 2017; Garvin et al., 2019; Ung et al., 2022), thinking like a computer (Corradini et al., 2017; Sands et al., 2018; Ung et al., 2022), and critical thinking (Bower et al., 2017; Garvin et al., 2019).

Results of the studies conducted with prospective teachers showed that they were more likely to conceive of CT as problem-solving (Lamprou & Repenning, 2018; Mouza et al., 2017; Yadav et al., 2011, 2014), thinking like a computer (Lamprou & Repenning, 2018; Yadav et al., 2011), using algorithms (Lloyd & Chandra, 2020; Yadav et al., 2014), and problem-solving by using technology (Bower & Falkner, 2015; Yadav et al., 2011). In comparison, they less frequently described CT as collecting/organizing/processing and testing information, scientific thinking, mathematical thinking, and logical thinking (Bower & Falkner, 2015; Looi et al., 2020), programming and thinking with the computer (Lamprou & Repenning, 2018; Looi et al., 2020; Umutlu, 2021), using technology and computer (Looi et al., 2020; Mouza et al., 2017; Yadav et al., 2014), and data analysis (Lloyd & Chandra, 2020). In conclusion, studies conducted either with teachers or prospective teachers yielded similar results on their preconceptions of CT. Both of them most frequently associate CT with problem-solving, using algorithms, programming, and using computers and technology. Yet to our knowledge, no study compares teachers' and prospective teachers' preexisting opinions about CT. Furthermore, existing studies have generally examined primary or secondary school teachers' or prospective teachers' preconceptions of CT and have rarely involved early childhood teachers or prospective teachers. Hence, more studies investigating and comparing early childhood teachers' and prospective teachers' preconceptions of CT are needed.

1.3 Teachers' and prospective teachers' computational thinking self-efficacy

With the increasing interest in embedding CT into education programs, there has been an argument about how to measure students' and teachers' CT competence. However, to be able to assess CT, we need to have a precise definition of the key concepts and competencies that CT includes (Grover & Pea, 2013; Tang et al., 2020). Unfortunately, there is no commonly accepted definition of the CT concept (Kalelioğlu et al., 2016; Lowe & Brophy, 2017; Shute et al., 2017) and in turn, there is no consensus on how to measure it (Bocconi et al., 2016; Çoban & Korkmaz, 2021; Román-González et al., 2017; Shute et al., 2017).

Up to now, many measures have been developed to assess CT competence. Most of these measures focus on students' acquisition of CT, while a few of them aim to evaluate teachers' or prospective teachers' CT competence (Haseski & İlic, 2019; Tang et al., 2020). In the scope of this study, we focus on the measures developed

for teachers and prospective teachers. Researchers and teacher educators have used either a performance-based assessment (Cetin & Andrews-Larson, 2016; Esteve-Mon et al., 2020; Jaipal-Jamani & Angeli, 2017; Kong et al., 2020) or a psychometric scale (Akgün, 2020; Çakır, Rosaline, et al., 2021; Çakır, Şahin, et al., 2021; Günbatar, 2019; Günbatar & Bakırcı, 2019; Hıdıroğlu & Hıdıroğlu 2021; Pala & Mihci Türker, 2021; Rich, Larsen, et al., 2021; Rich, Mason, et al., 2021). With these tools, they have assessed either primary and secondary school teachers' and prospective teachers' computing skills (Cetin & Andrews Larson, 2016; Esteve-Mon et al., 2018; Jaipal-Jamani & Angeli 2017; Kong et al., 2020) or self-efficacy beliefs in CT (Akgün, 2020; Çakır, Rosaline, et al., 2021; Çakır, Şahin, et al., 2021; Günbatar, 2019; Günbatar & Bakırcı, 2019; Hıdıroğlu & Hıdıroğlu 2021; Pala & Mihci Türker, 2021; Rich, Larsen, et al., 2021; Rich, Mason, et al., 2021).

In the current study, early childhood teachers' and prospective teachers' CT skills are measured as perceived self-efficacy. More specifically, we evaluate their perception of their ability to competently perform CT-related skills. Bandura (1997) defines self-efficacy as "a belief in one's capabilities to organize and execute courses of action required to produce given attainments" (p. 3). Román-González et al., (2018) restate the concept of self-efficacy as "an individual's judgment of his/her ability to perform a task within a specific domain" (p. 442). This personal sense of efficacy determines whether an individual carries out an action (Bandura, 1977). When applied to the scope of the current study, this means that teachers and prospective teachers will be more inclined to think computationally as they believe that they are competent in problem-solving, creativity, algorithmic thinking, cooperativity, and critical thinking. That, in turn, might influence their competence in teaching CT (Rich, Larsen, et al., 2021). A study examining the influence of prospective teachers' self-efficacy beliefs about their CT skills on their STEM teaching intentions provides a shred of evidence for this assumption (Günbatar & Bakırcı, 2019).

Bandura (1986) also argues that self-efficacy beliefs are as important as skills in learning new concepts and influence how one performs since having a high sense of efficacy strengthens one's motivation and increases his/her performance. It has been proven that self-efficacy is a strong predictor of one's performance (e.g., Lee & Stankov 2018; Stajkovic et al., 2018). Hence, self-efficacy perception could be considered a source that provides information about one's potential for being competent in doing something (Bandura, 1982; Kukul & Karataş, 2019; Rich, Mason, et al., 2021). Regarding self-efficacy as an indicator of one's actual level of competence, this study attempts to shed some light on how early childhood teachers and prospective teachers perceive themselves in terms of problem-solving, creativity, algorithmic thinking, cooperativity, and critical thinking skills that are involved in CT, as well as to what extent their perceived competence in CT differ.

More studies measuring teachers' and prospective teachers' CT self-efficacy have been conducted in Turkey and used the same measurement tool developed by Korkmaz et al., (2017), while relatively fewer studies on that subject have been carried out abroad, specifically in the US, and used the psychometric scale developed by the researchers (Rich, Larsen, et al. 2021; Rich, Mason, et al., 2021). Some of them have studied with participants who majored in various fields of education (e.g., Early Childhood Education, Primary Education, Science Education, etc.; Akgün 2020;

Çakır, Rosaline, et al., 2021; Çakır, Şahin, et al., 2021; Günbatar, 2019; Günbatar & Bakırcı, 2019), while others have involved participants certified in Computer Education and Instructional Technology (Pala & Mıhçı Türker, 2021), Primary Education (Rich, Larsen, et al. 2021; Rich, Mason, et al., 2021), or Mathematics Education (Hıdıroğlu & Hıdıroğlu, 2021). Similar to the tendency observed in studies on early childhood teachers' and prospective teachers' preconceptions of CT, their perceived confidence in CT has been rarely investigated (Haseski & İlic, 2019). Most of the studies have been conducted either with teachers (Çakır, Şahin, et al., 2021; Hıdıroğlu & Hıdıroğlu, 2021; Rich, Larsen, et al. 2021; Rich, Mason, et al., 2021) or prospective teachers (Akgün, 2020; Çakır, Rosaline, et al., 2021; Günbatar & Bakırcı, 2019; Pala & Mıhçı Türker 2021). Findings have showed that prospective teachers' CT self-efficacy is moderate (Akgün, 2020; Çakır, Rosaline, et al., 2021), while teachers' CT self-efficacy is very high (Çakır, Şahin, et al., 2021; Hıdıroğlu & Hıdıroğlu, 2021) in Turkey and moderate in the US (Rich, Mason, et al., 2021). The only study comparing the self-efficacy perceptions of teachers with those of prospective teachers in CT showed significantly higher scores for teachers (Günbatar, 2019). Although the differences between teachers and prospective teachers in the self-efficacy beliefs in particular content areas, such as technological pedagogical content knowledge (TPACK; e.g., Dong et al., 2015; Luik et al., 2018; Ma & Baek 2020; Turgut, 2017) have been quite documented in the literature, more research is needed to validate the observed differences between teachers and prospective teachers in terms of CT self-efficacy.

In conclusion, further evidence about teachers' and prospective teachers' preconceptions of and self-efficacy in CT is needed to determine the knowledge and the skills that they each need to effectively embed CT into daily classroom learning experiences and support children's CT processes, as well as guide researchers and teacher educators in designing educational programs aligned with these needs. In addition, considering that children's CT processes should be supported from an early age, the research should include early childhood teachers and prospective teachers. Taken all together, this study aims to examine the preconceptions and self-efficacy perceptions of early childhood teachers and prospective teachers about CT. This exploratory study sought to address the following research questions:

1. How do early childhood teachers and prospective teachers conceive of CT?
2. Do preconceptions of early childhood teachers differ from those of prospective teachers in CT?
3. Does CT self-efficacy of early childhood teachers differ from that of prospective teachers?

2 Method

This study has employed the descriptive survey design that aims to collect and analyze data to determine the opinions, perceptions, or behaviors of a large group (Stockemer, 2019). Since there is limited research on the preconceptions and the self-efficacy of early childhood teachers and prospective teachers about CT in the literature, we have utilized this design to systematically describe and compare the opinions

and the perceptions of this specific group about the given phenomenon. In addition, due to the Covid 19 pandemic, it has been hard to find participants who volunteer to attend research in person. Thus, we have decided to use an online survey which enables us to collect data at distance without risking participants' health.

2.1 Participants

After ethics approval was received from the university research ethics board, early childhood teachers and prospective teachers were invited to fill out the online survey measuring their preconceptions and self-efficacy about CT in the spring of the 2020–2021 academic year in Turkey. Informed consent was obtained from each participant who filled out the survey. Even though a nationwide early childhood curriculum and teacher education program is used in Turkey, geographical location could have a significant effect on teachers' and prospective teachers' CT experiences due to the socioeconomic differences among the regions of Turkey. Therefore, following the snowball sampling procedure, we used the connections of the consenting participants to expand the geographical representation of the sample (Baltar & Brunet, 2012; Parker et al., 2019; Stockemer, 2019). Even though this choice limits the generalizability of the sample, the extent of the geographical representation of the sample was more similar to teachers and prospective teachers in general.

Data were obtained from a total of 142 participants, 64 of whom were teachers and 78 were prospective teachers. Yet, one of the teachers' total scores on the self-efficacy scale was determined as an outlier, she was excluded from the data set, so analyses were conducted on the data obtained from 141 participants. As shown in Tables 1 and 88.9% of the teachers and 79.5% of the prospective teachers were female. Of the 63 teachers, 31.7% had less than 5 years of teaching experience, 25.4% had teaching experience between 5 and 9 years, and the remaining 42.9% had 10 years or more of teaching experience. Of the 78 prospective teachers, 2.6% were freshmen, 29.5% were sophomores, 51.3% were juniors, and 16.7% were seniors.

Table 1 *The Demographic Characteristics of The Study Participants*

	Teachers (<i>n</i> =63) %	Prospective Teachers (<i>n</i> =78) %
Gender (Female)	88.9	79.5
Years of teaching experience		
Less than 5 years	31.7	
5 to 9 years	25.4	
10 years or more	42.9	
Years of school		
Freshmen		2.6
Sophomores		29.5
Juniors		51.3
Seniors		16.7

2.2 Measures

2.2.1 Teachers' and prospective Teachers' preconceptions of computational thinking

The survey developed by Sands et al., (2018) was used to measure early childhood teachers' and prospective teachers' preexisting opinions about CT. The survey consists of 10 items that have been created based on the findings obtained in qualitative studies conducted by Yadav et al., (2011, 2014). Items start with the phrase "Computational thinking involves ..." and continue with a list of 10 skills that may or may not be related to CT. The participants are asked to answer whether these skills belong to CT by choosing one of five possible response categories (strongly agree=1, agree=2, disagree=3, strongly disagree=4, do not know=5). Based on the literature, Sands et al., (2018) identified problem-solving, using heuristics/algorithms, logical thinking, and thinking like a computer as CT-related skills while they determined doing mathematics, using computers, knowing how to use a computer, using technology in teaching and playing online games as unrelated to CT. Also, they stated that there are different opinions in the literature about the relationship between coding/programming skills and CT. The Cronbach Alpha they calculated was 0.92, while that we obtained in this study was 0.73.

2.2.2 Teachers' and prospective Teachers' computational thinking self-efficacy

The *Computational Thinking Scale* developed by Korkmaz et al., (2017) was used to measure the perceived self-efficacy of early childhood teachers and prospective teachers toward CT. The five-point Likert-type scale is composed of 29 items assessing five aspects of CT: creativity, algorithmic thinking, cooperativity, critical thinking, and problem-solving. The creativity subscale involves eight items that have factor loadings ranging from 0.71 to 0.55. The algorithmic thinking scale consists of six items whose factor loading values vary between 0.83 and 0.67. The cooperativity subscale is composed of four items that have factor loading values varying between 0.84 and 0.69. The critical thinking subscale consists of five items with factor loadings ranging from 0.76 to 0.53. The problem-solving subscale involves six items whose factor loading values vary between 0.72 and 0.49. The Cronbach Alpha value is 0.82 for the entire scale, 0.84 for creativity, 0.87 for algorithmic thinking, 0.87 for cooperativity, 0.78 for critical thinking, and 0.73 for problem-solving. The participants are asked to choose one of the following response options: "Always (5)," "Generally (4)," "Sometimes (3)," "Rarely (2)," "Never (1)." Possible scores on the scale range from 29 to 145. Only items on the problem-solving subscale are written negatively. The responses in this subscale were recoded before the analysis. Since the data collected in the current study did not confirm the factors obtained in the original study, we chose to use the scores on the entire scale. The factor loading values for the entire scale varied between 0.76 and 0.42, and the Cronbach Alpha value was 0.91.

2.3 Data Analysis

Due to the ordinal nature of the scale, descriptive and non-parametric statistics were used in the analyses of the data on early childhood teachers' and prospective teachers' preconceptions of CT. First, the percentage of possible response categories for each item was calculated separately for the teacher and the prospective teacher groups. Then, the Mann-Whitney U test was carried out to compare preconceptions of teachers with that of prospective teachers. Participants who chose the "Don't know" response category on each item were excluded from the analysis. Before running the Mann-Whitney U test, Levene's test based on median and adjusted degrees of freedom was conducted to test the similarity of the shapes of the distributions of the scores on each item across groups. The findings confirmed the similarity in the shapes of the distributions across the groups ($p > .05$).

Descriptive statistics and t-test were used in the analysis of data on early childhood teachers' and prospective teachers' self-efficacy perceptions in CT. First, the self-efficacy scores of teachers and prospective teachers were separately examined for extreme values and normal distribution. The score of a participant in the teacher group was identified as an extreme value and removed from the data set. The normality tests showed that the scores were distributed close to normal in both the teacher and the prospective teacher groups ($p > .05$). Finally, the independent sample t-test was carried out to test whether there was a significant difference in CT self-efficacy between the two groups. Levene's test confirmed that the data met the assumption of the equality of variances of the distributions of the scores in both groups ($(F=1.139)=0.15, p=.70$).

3 Results

3.1 Teachers' and prospective teachers' preconceptions of computational thinking

The percentages of possible response categories for each item measuring preexisting opinions about CT were given separately for the teacher and the prospective teacher groups in Table 2. While all teachers reported that CT involved problem-solving, using heuristics/algorithms, and logical thinking, almost all of them held the opinion that coding/programming (98.5%) and doing mathematics (98.4%) were related to CT. Similar to teachers, but at a relatively lower rate, prospective teachers associated CT with logical thinking (93.6%), problem-solving (92.3%), and using heuristics/algorithms (88.5%). Many prospective teachers also reported that CT involved coding/programming (85.9%) and doing mathematics (85.9%). Furthermore, about half of the teachers thought that CT involved thinking like a computer (49.2%), while more than half of the prospective teachers held this opinion (69.2%).

The majority of both teachers and prospective teachers associate CT with technology. Teachers stated that CT was associated with using technology in teaching (90.5%), using computers (88.9%), knowing how to use a computer (84.1%), and playing online games (46.1%). Similarly, prospective teachers conceived of CT as

Table 2 *Early Childhood Teachers' and Prospective Teachers' Preconceptions of Computational Thinking*

	Teachers					Prospective Teachers				
	Strongly agree	Agree	Disagree	Strongly disagree	Do not know	Strongly agree	Agree	Disagree	Strongly disagree	Do not know
Problem-solving	52.4	47.6	-	-	-	37.2	55.1	1.3	-	6.4
Using heuristics/ algorithms	47.6	52.4	-	-	-	28.2	60.3	2.6	-	9.0
Logical thinking	58.7	41.3	-	-	-	37.2	56.4	-	-	6.4
Thinking like a computer	17.5	31.7	25.4	3.2	22.2	15.4	53.8	14.1	-	16.7
Coding/ programming	42.9	55.6	1.6	-	-	16.7	69.2	3.8	-	10.3
Doing mathematics	33.3	65.1	-	-	1.6	29.5	56.4	7.7	-	6.4
Using computers	34.9	54.0	3.2	-	7.9	29.5	57.7	5.1	-	7.7
Knowing how to use a computer	31.7	52.4	6.3	-	9.5	23.1	56.4	11.5	-	9.0
Using technology in your teaching	38.1	52.4	1.6	-	7.9	35.9	55.1	1.3	-	7.7
Playing online games	15.9	30.2	30.2	4.8	19.0	11.5	37.2	30.8	6.4	14.1

Note. Values in the table indicate percentages

using technology in teaching (91%), using computers (87.2%), knowing how to use

a computer (79.5%), and playing online games (48.7%).

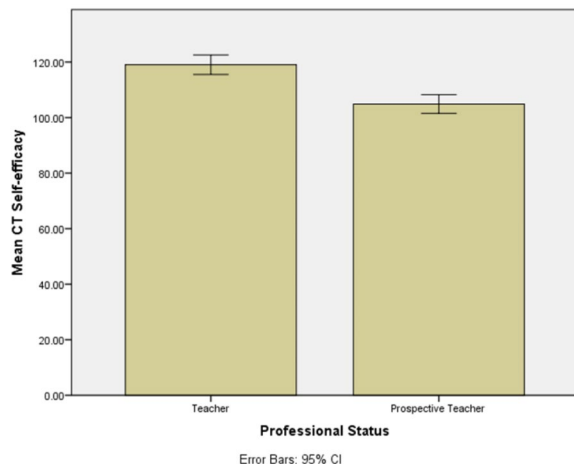
The results of the Mann-Whitney U test, testing the differences between teachers' and prospective teachers' preconceptions of CT, are given in Table 3. The findings revealed significant differences between teachers and prospective teachers in

Table 3 Comparisons of Early Childhood Teachers' and Prospective Teachers' Preconceptions of Computational Thinking

		n	Mean Rank	Sum of Ranks	U	p
Problem-solving	Teachers	63	63.64	4009.50	1993.50	0.12
	Prospective teachers	73	72.69	5306.50		
Using heuristics/algorithms	Teachers	63	61.07	3847.50	1831.50	0.03*
	Prospective teachers	71	73.20	5197.50		
Logical thinking	Teachers	63	61.56	3878.50	1862.50	0.03*
	Prospective teachers	73	74.49	5437.50		
Thinking like a computer	Teachers	49	61.90	3033.00	1377.00	0.17
	Prospective teachers	65	54.18	3522.00		
Coding/programming	Teachers	63	58.10	3660.00	1644.00	0.00*
	Prospective teachers	70	75.01	5251.00		
Doing mathematics	Teachers	62	65.15	4039.50	2086.50	0.36
	Prospective teachers	73	70.42	5140.50		
Using computers	Teachers	58	62.95	3651.00	1940.00	0.42
	Prospective teachers	72	67.56	4864.00		
Knowing how to use a computer	Teachers	57	59.98	3419.00	1766.00	0.16
	Prospective teachers	71	68.13	4837.00		
Using technology in your teaching	Teachers	58	64.69	3752.00	2041.00	0.80
	Prospective teachers	72	66.15	4763.00		
Playing online games	Teachers	51	58.06	2961.00	1635.00	0.67
	Prospective teachers	67	60.60	4060.00		

Note. Responses on items were ranked from strongly agree (1) to strongly disagree (4). * $p < .05$

Fig. 1 Comparison of Early Childhood Teachers' and Prospective Teachers' Computational Thinking Self-efficacy



the associations of CT with using heuristics/algorithms ($U=1831.50$, $p<.05$), logical thinking ($U=1862.50$, $p<.05$), and coding/programming ($U=1644.00$, $p<.05$). The mean ranks of teachers on the related items were lower than those of prospective teachers, indicating that teachers reported stronger associations between CT and using heuristics/algorithms, logical thinking, and coding/programming.

3.2 Teachers' and prospective teachers' computational thinking self-efficacy

Independent samples t-test was conducted to test whether there was a difference between early childhood teachers' and prospective teachers' CT self-efficacy. As seen in Fig. 1, the mean scores of teachers and prospective teachers on the CT self-efficacy scale were both quite high, yet the mean score of teachers differed significantly from that of prospective teachers [$t(139)=5.775$, $p<.00$]. Teachers perceived themselves ($\bar{X}=119.04$) as more competent than prospective teachers ($\bar{X}=104.87$) in terms of CT skills.

4 Discussion and conclusion

This study examines how early childhood teachers and prospective teachers conceive of CT and perceive themselves in terms of CT skills. In the light of the related literature, we first discuss the study findings on early childhood teachers' and prospective teachers' preconceptions and then their perceived self-efficacy.

4.1 Teachers' and prospective teachers' preconceptions of computational thinking

The study findings show that in general, early childhood teachers and prospective teachers conceive of CT similarly. More specifically, all of the teachers and most of the prospective teachers associate CT with logical thinking, problem-solving, and using heuristics/algorithms, but prospective teachers relate CT with logical thinking and using heuristics/algorithms at a lower rate than teachers. These findings align with the findings of the previous studies conducted with teachers (Bower et al., 2017; Corradini et al., 2017; Garvin et al., 2019; Morreale et al., 2012; Sands et al., 2018; Walton et al., 2020; Yadav et al., 2018), as well as with prospective teachers (Lamprou & Repenning, 2018; Lloyd & Chandra, 2020; Yadav et al., 2011, 2014) specializing in primary and secondary education. Since the comparisons of teachers' and prospective teachers' preconceptions of CT have not yet been studied widely, this study can contribute to the literature by revealing that there might be a difference between the two groups in the preconceptions of CT. This empirical evidence could lead to the differentiation of the scope of the education programs on CT prepared for teachers and prospective teachers to meet the unique needs of the two groups. For instance, recently, in the scope of a project funded by the Erasmus+ Programme, an undergraduate course has been designed to support early childhood prospective teachers' pedagogical content knowledge in algorithmic thinking (Figueiredo et al., 2021). The current study provides empirical evidence for the necessity of such programs in early

childhood teacher education programs. A recent study also showed that prospective teachers perceived themselves as least competent in problem-solving and algorithmic thinking (Çakır, Rosaline, et al., 2021). Yet, more studies are needed to examine the existence and reasons for this difference in larger samples.

Early childhood teachers' and prospective teachers' preexisting opinions about the associations between CT and logical thinking, problem-solving, and using heuristics/ algorithms seem to align with the consensus on the skills involved in CT. Despite the lack of agreement on the definition of CT, problem-solving, algorithmic thinking, and abstraction are the three most accepted components of CT (Kalelioğlu et al., 2016). For example, partially supporting teachers' and prospective teachers' preconceptions of CT, Aho (2012) defined CT as *formulating problems and algorithms*. In addition, compatible with the preconceptions of the study participants, Wing (2008) argues that CT includes problem-solving, critical thinking, abstraction, and analytical and algorithmic thinking. At this point, it is important to note that CT-specific problem-solving should be differentiated from generic problem-solving (Cabrera, 2019) since CT-specific problem-solving should generate solutions that could be executed by a computational agent (Denning, 2017; Wing, 2011). In future research, researchers and teacher educators should ask teachers and prospective teachers to specify the kind of problem-solving skills that they relate to CT.

Another finding of the study indicates that almost all of the teachers and most of the prospective teachers relate CT with coding/programming and doing mathematics. Yet, teachers recite a stronger association between CT and coding/programming. Similarly, previous studies reported a high frequency for teachers (Bower et al., 2017; Garvin et al., 2019; Sands et al., 2018; Yadav et al., 2018), and a relatively low frequency for prospective teachers (Lamprou & Repenning, 2018; Looi et al., 2020; Umutlu, 2021) in the association between CT and coding/programming. Some researchers have acknowledged this preconception of CT as a misconception (Corradini et al., 2017; Garvin et al., 2019; Lamprou & Repenning, 2018; Ung et al., 2022). In most CT definitions, it is emphasized that CT is not equal to programming (CS), but they are deeply connected (Mouza et al., 2017; Qualls & Sherrell, 2010; Voogt et al., 2015; Wing, 2006). CT involves thinking and acting like a computer scientist while solving problems and programming fosters this process (Cabrera, 2019; Denning, 2009, 2017; Grover & Pea, 2013; Voogt et al., 2015). Therefore, researchers and teacher educators should use programming as a learning tool to make CT concepts understandable (Bocconi et al., 2016; Buitrago Flórez et al., 2017), yet they should show non-programming activities as examples of CT to facilitate teachers' and prospective teachers' conceptualization of CT beyond programming (Barr & Stephenson, 2011; Cabrera, 2019). In addition, similar to the study participants, primary and secondary school teachers (Garvin et al., 2019; Rich et al., 2019; Sands et al., 2018; Ung et al., 2022) and prospective teachers (Bower & Falkner, 2015; Looi et al., 2020; Yadav et al., 2011) tend to associate CT with mathematics since there are some common terms, such as algorithmic thinking, decomposition, and automation, used both in CT and mathematics (Rich et al., 2019). In-depth analyses are needed to reveal the opinions of early childhood teachers and prospective teachers on this issue.

In the current study, teachers and prospective teachers highly and closely recite that CT is related to the skills of using technology in teaching, using a computer, and

knowing how to use a computer, while nearly half of them report that it includes the skill of playing online games. Previous studies also showed teachers' and prospective teachers' preexisting opinions about CT concerning using computers and technology (Bower & Falkner, 2015; Bower et al., 2017; Corradini et al., 2017; Garvin et al., 2019; Lamprou & Repenning, 2018; Sands et al., 2018; Ung et al., 2022; Yadav et al., 2011, 2014, 2018). Some researchers identify this preconception as a misconception (Bower & Falkner, 2015; Bower et al., 2017; Corradini et al., 2017; Garvin et al., 2019; Sands et al., 2018; Ung et al., 2022). Yet, this interpretation might be incorrect (Barr & Stephenson, 2011; Grover & Pea, 2013), since some of the definitions of CT involve plugged and unplugged problem-solving (Sykora, 2021). More specifically, using technology and CT are not completely unrelated, but CT does not always require using technology and all technology use does not trigger CT. Creating a new framework based on the idea that certain technology requiring the use of skills related to CT could support the CT process might make teachers' and prospective teachers' conceptualization of CT more precise (Cabrera, 2019). In addition, the exact reason why teachers and prospective teachers associate CT with technology and computers is not yet known, so an in-depth analysis of this preconception in future research is needed.

About half of the teachers and more than half of the prospective teachers stated that CT includes thinking like a computer. There are opponents of this preconception (Lamprou & Repenning, 2018; Ung et al., 2022; Wing, 2006) since CT does not mean to make humans think like computers (Grover & Pea, 2018; Lu & Fletcher, 2009). To decide whether this preconception is related to CT or not, we should understand what the participants mean by *thinking like a computer*. If *thinking like a computer* is perceived as *thinking by using the working principles of the computer*, we could conclude that the participants are not completely mistaken since in the definition of CT and CT-related skills, the concepts such as creating algorithms (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019; Kazimoglu et al., 2012), the calculation (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019), pattern recognition, testing (Grover & Pea, 2018), and debugging (Aho, 2012; Hemmendinger, 2010; Kazimoglu et al., 2012) on which computer processing logic is based are frequently used. Researchers and teacher educators should eliminate the existing uncertainty about this preconception by discussing the similarities and differences between humans' and computers' information processing with teachers and prospective teachers (Cabrera, 2019; Grover & Pea, 2018).

In conclusion, the lack of knowledge about CT is the greatest challenge for most early childhood teachers, which prevents them from noticing and accurately identifying instances of CT in children's free play (Kotsopoulos et al., 2021). In addition, young children need explicit scaffolding to engage in CT and elaborate their CT process (Angeli & Valanides, 2020; Georgiou & Angeli, 2021; Newhouse et al., 2017). Therefore, well-informed and well-prepared early childhood teachers who can design age-appropriate plugged and unplugged activities to support children's development in CT are needed (Murcia et al., 2018). To design effective learning experiences for early childhood teachers and prospective teachers, empirical evidence on their preexisting opinions about CT should be obtained.

The current study has attempted to contribute to the body of knowledge by examining a group of early childhood teachers' and prospective teachers' preconceptions of CT. Even though CT has not yet been embedded in the Turkish early childhood education program, teachers and prospective teachers who participated in the study seem to have preexisting opinions about the concept of CT that mostly align with primary and secondary school teachers' and prospective teachers' preconceptions. Yet, due to the structured nature of the measurement tool, as well as the methodology (i.e., written responses) utilized both in the current study and in previous studies (Cabrera, 2019; Sands et al., 2018; Yadav et al., 2018), detailed information both on the participants' preconceptions of CT and the possible reasons for the observed differences in the opinions of the two groups has not yet been obtained. Conducting interviews with unstructured or semi-structured questions could provide more precise information on early childhood teachers' and prospective teachers' preconceptions of CT. That, in turn, enables researchers and teacher educators to design meaningful learning experiences for them ameliorating the associations between CT and problem-solving, algorithmic thinking, mathematics, coding/programming, thinking like a computer, and using computers and technology. Empirical evidence of the positive effects of such professional development and education programs has been obtained in previous studies (e.g., Bower & Falkner 2015; Bower et al., 2017; Gadanidis et al., 2017; Simmonds et al., 2019; Walton et al., 2020).

4.2 Teachers' and prospective teachers' computational thinking self-efficacy

The finding of the current study indicates that the self-efficacy perceptions of both early childhood teachers and prospective teachers in CT are high. Partially supporting these results, previous studies reported high to moderate self-efficacy perceptions for teachers (Çakır, Şahin, et al., 2021; Hıdıroğlu & Hıdıroğlu, 2021; Rich, Mason, et al., 2021), while they revealed moderate self-efficacy beliefs for prospective teachers (Akgün, 2020; Çakır, Rosaline, et al., 2021). The observed discrepancy might be explained by the differences in the participants' majors. The participants of the current study specialize in early childhood education, whereas those of previous studies mostly major in primary or secondary education. Since early childhood teachers' and prospective teachers' competency in CT has been rarely investigated (Haseski & Ilic, 2019), further evidence is needed to validate the level of self-efficacy perceptions of those who majored in early childhood education.

Another finding of the study shows that in comparison to prospective teachers, teachers perceive themselves as more competent in CT-related skills, namely problem-solving, creativity, critical thinking, cooperativity, and algorithmic thinking. Similarly, Günbatar (2019) studying with participants from different majors including early childhood education reported a significant difference between teachers' and prospective teachers' CT self-efficacy. To further investigate the causes of the observed difference, he conducted interviews with teachers who stated that the opportunities, situations, and requirements encountered in professional life, such as the teaching process, gaining experiences in instructional technologies, discipline in work, having autonomy, professional responsibilities, understanding others, and cooperation and conflict with colleagues, students, and administrators, improve their

CT-related skills. Supporting these findings, Akgün (2020) argues that having high CT self-efficacy could positively contribute to the skills of problem-solving, algorithmic thinking, designing systems, and understanding human behavior. Yet, prior research has some limitations. The interviews were conducted with only teachers, excluding prospective teachers. To comprehensively evaluate the similarities and differences in the underlying thought processes that teachers and prospective teachers utilize when they judge their competence in CT, interviews should be conducted with both groups. In addition, interview questions were structured based on the assumption that professional life influenced teachers' CT skills. Thus, these questions directed teachers' attention to the impact of their professional life on their problem-solving, critical thinking, cooperativity, algorithmic thinking, and creative thinking skills, without checking how teachers conceptualize these skills concerning CT. This approach overlooks other sources of information influencing teachers' self-efficacy in CT-related skills, such as previous personal life experiences in which they perform successfully, vicarious experiences obtained via the observation of others' performance, verbal persuasion about their performance constructed by others, as well as themselves, and emotional arousal related to the perceived performance (Bandura, 1997). Taking a more comprehensive approach, namely Bandura's self-efficacy theory, a further in-depth analysis should be conducted to reveal the sources of the similarities and differences in CT self-efficacy of teachers and prospective teachers.

Bandura (1986) argues that self-efficacy beliefs are as important as skills in determining whether an individual performs specific competencies in future situations, it is important to enhance teachers, as well as prospective teachers' perceptions of their CT competencies to ensure they will be able to model the use of CT-related skills for children and support children's use of these skills in solving real-life problems, as well as those in key school content areas (ISTE, 2021b; NRC, 2010). Research has shown that appropriate training programs can improve teachers' and prospective teachers' perceived confidence in CT (e.g., Bers et al., 2013; Corradini et al., 2017; Jaipal-Jamani & Angeli, 2017; Kalogiannakis & Papadakis, 2017; Pala & Mihci Türker, 2021; Rich, Mason, et al., 2021). Considering the fact that the increase in mastery experiences can positively affect self-efficacy (Bandura, 1977; Román-González et al., 2018), these programs should aim to improve teachers' and prospective teachers' understandings of CT, as well as to design experiences in which they can successfully practice CT (Rich, Mason, et al., 2021). Existing CT training programs have mostly provided experiences for participants through plugged activities (Bers et al., 2013; Hunsaker & West, 2020; Jaipal-Jamani & Angeli, 2017; Kalogiannakis & Papadakis, 2017; Pala & Mihci Türker, 2021; Rich, Larsen, et al., 2021; Rich, Mason, et al., 2021), yet it is crucial to have them also experience the use of CT skills in unplugged activities (Kotsopoulos et al., 2017; Murcia et al., 2018). Supporting this claim, current literature focusing on CT skills in young children argues that unplugged daily activities are more suitable for them to experience CT since they can learn best through concrete, hands-on, and play-based experiences (Lavigne et al., 2020; Lee et al., 2022; Lee & Junoh, 2019). That means designing professional development programs that facilitate teachers' competence to incorporate unplugged CT activities with daily practices is vital, especially in early childhood education.

Considering the ongoing debate on the lack of comprehensive and accurate assessment of CT competence (Haseski & İlic, 2019; Lowe & Brophy, 2017; Shute et al., 2017; Tang et al., 2020), we need to take the study findings in caution. As far as we know, prior research on teachers' and prospective teachers' CT assessments in Turkey, including the present study, has relied on their self-reports that reveal self-efficacy perceptions (Akgün, 2020; Çakır, Rosaline, et al., 2021; Çakır, Şahin, et al., 2021; Günbatar, 2019; Günbatar & Bakırcı, 2019; Hıdıroğlu & Hıdıroğlu 2021; Pala & Mihçı Türker, 2021). The self-efficacy measures are considered proxies of teachers' actual level of CT competence (Rich, Mason, et al., 2021). Yet, the accuracy of the self-assessment is contingent on the participants' self-awareness about their skills, as well as their ability to evaluate themselves objectively. Thus, we do not know for sure to what extent these self-reports are biased due to acquiescence, social desirability, or overrating (He et al., 2014; Stockemer, 2019).

In recent years, researchers have argued that whether CT is mainly a way of thinking, as well as acting is being argued in the literature since it can be displayed with the use of certain skills, which in practice can become observable reference points for performance-based assessment tools for CT skills (Çoban & Korkmaz, 2021; Shute et al., 2017). For instance, Çoban & Korkmaz (2021) concurrently utilized a performance-based assessment and a self-report to measure high school students' CT competence and found that the performance-based measurement tool better estimated high school students' CT skill level since students overestimated their actual skill level with the psychometric scale. Similarly, participants of the present study report a high personal sense of self-efficacy about their CT competence. Since a performance-based tool has not been used in the study, we cannot validate the level of self-reported CT competence. There are some performance-based assessments designed abroad for evaluating teachers' CT competence in the context of computing (Cetin & Andrews Larson, 2016; Esteve-Mon et al., 2018; Jaipal-Jamani & Angeli 2017; Kong et al., 2020), which have been criticized for degrading CT solely to the programming skill (Lowe & Brophy, 2017; Tang et al., 2020). Hence, to accurately and comprehensively assess teachers' and prospective teachers' CT competence, researchers and teacher educators should develop valid and reliable performance-based assessment tools measuring CT-related skills, such as decomposition, pattern recognition, problem-solving, algorithmic thinking, abstraction, logical thinking, and debugging (Grover & Pea, 2018; Rich, Mason, et al., 2021; Román-González et al., 2017).

In conclusion, in this study, we aim to investigate early childhood teachers' and prospective teachers' preexisting opinions about CT and perceptions about their CT skills. Participating teachers' and prospective teachers' preconceptions of CT are generally similar and align with the literature. Yet, the magnitude of the reported associations between CT and logical thinking, using algorithms, and coding/programming differs between the two groups. Despite the lack of clarification on the sources of the observed findings, this study contributes to the literature by being the first attempt concurrently investigating the preconceptions of early childhood teachers and prospective teachers about CT and shedding some light on the potential similarities and differences between the two groups. Furthermore, teachers in the study report higher confidence in their ability to think computationally than prospective teachers. Though we have a shred of evidence about the difference in CT self-efficacy

between the two groups, further investigations are needed to better understand the sources of this difference.

Finally, considering Fang's (1996) argument, we have hypothesized that the level of accuracy in the preconceptions about CT may play a role in CT self-efficacy. Thus, we have attempted to examine whether the participants' CT self-efficacy depends on the accuracy of their preconceptions about CT. Given the observed distribution and the ordinal nature of the scale, we have first created a four-level categorical variable for preconceptions based on the opinions of the developers of the scale: 1=teachers with less accurate preconceptions (50% or less); 2=teachers with more accurate preconceptions (60% or more); 3=prospective teachers with less accurate preconceptions (50% or less); 4=prospective teachers with more accurate preconceptions (60% or more). Then, we tested the data for the assumptions of the Kruskal Wallis Test. Unfortunately, we could not meet the assumption for the similarity of the shapes of the distributions of the self-efficacy scores across groups. Thus, we could not report the findings for our hypothesis. Nevertheless, we ran the analysis to see whether there was any support for our hypothesis and we found that CT self-efficacy might be contingent on the level of accuracy in the preconceptions. As per the mean rank orders, teachers with more accurate preconceptions had the highest CT self-efficacy, followed by teachers with less accurate preconceptions, prospective teachers with more accurate preconceptions, and prospective teachers with less accurate preconceptions, successively. When we conducted pairwise comparisons with the Mann-Whitney U test to see which groups significantly differ from each other, we found that regardless of the level of accuracy in preconceptions, teachers had higher CT self-efficacy than prospective teachers. These results imply that it is worth investigating the link between preconceptions and self-efficacy in the context of CT in future research.

Declaration

Conflict of interest None.

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