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Analysis of the relation between computational thinking skills and various variables with the structural equation model

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ABSTRACT

The aim of this study is to determine how much various variables explain students' computational thinking (CT) skills. Furthermore, it was aimed to produce a model that explains and predicts the relations between computational thinking skills and various variables. Study group consists of 156 students who were studying in 5–12. Class in 2015–2016 academic year in different schools in Ankara. Relational screening model was used in this research. Two different data collection instruments were used in this research. The first one is "Personal Information Form". The second one is "Computational Thinking Skills Scale". Structural Equation Model was used in data analysis so as to produce a model that explains and predicts the relations between computational thinking skills and various variables. According to research results, it was found that computational thinking skill was highly predicted by variables, respectively; "thinking styles, academic success in mathematic class, attitude against mathematic class".

1. Introduction

Developments in computer science have brought about profound effects in economic and social life. Today, however, almost everyone, regardless of age, is expected to have some basic computing skills in parallel with the emerging developments in technology (Wing, 2014). Darling-Hammond (2008, pp. 1–9) emphasizes that we should prepare students for the future as individuals who have the competencies to use undiscovered technologies that we do not currently know in order to solve problems. In this context, it is natural that there are differences in competencies and anticipations expected from individuals. In addition to these stunning developments in technology, it is emphasized that people from all age groups should possess some computational skills at a basic level. (Kalelioğlu, Gülbahar & Kukul, 2016). At the bottom of this assumption the finding which states that individuals have to use digital technologies by critically thinking in order to acquire knowledge and skills and to solve the problems that they confront both in their educational and everyday lives lies (Wing, 2006); As Wing (2006) notes related to the skill of computational thinking, "Ubiquitous computing was yesterday's dream that became today's reality; computational thinking is tomorrow's reality. In this context, Wing (2014) considers that

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computational thinking skills are essential for every individual towards the mid-21st Century, such as reading, writing and basic mathematics skills.

Computational thinking is not a new concept; it is an important skill that has been emphasized in the context of computer science since the 1960s (Denning, 2009; Grover & Pea, 2013). Early on, CT had been seen as a proficiency to be acquired by computer scientists, which is considered important in the history of computer science yet this mentality has been changed especially by Wing's (2006) determination that CT is one of the basic competencies that everyone should acquire. The determination made by Wing has been responded within a very short period of time and has found a place in the literature broadly (Grover & Pea, 2013). At the same time, there are a number of institutions that develop international standards in the field of education (The International Society for Technology in Education [ISTE], Computer Science Teachers Association [CSTA], The National Research Council [NRC]), policy makers and large scale companies (Google, Microsoft etc.) have supported this idea and has made a great contribution to considering CT as a competency that should be acquired by everyone even at the basic level and as an important 21st century skill that is important in terms of the preparing individuals for the future world. In the 21st century, it is expected from the individuals to have a productive role by using technologies that exist instead of being the ones who consume technology (Kalelioğlu, 2015; Resnick et al., 2009). In this framework, it can be said that development of individuals' creativity and problem-solving skills should be improved. Kong (2016) stated that the development of computational thinking has become essential for young people in order to raise a future generation that acquires skills of creativity and problem-solving in conjunction with technology. In this context, ISTE (2011) emphasizes that young people should be prepared to become computational thinkers who understand how tomorrow's problems can be solved by using present-day technologies. Thus, it can be said that the CT related skills can improve the problem solving and critical thinking ability by benefitting from the power of information processing. In addition, CT has the potential to expand its capacity and ability to resolve individuals' problems unprecedentedly (ISTE, 2011). On the other hand, it can be said that CT competence has a remarkable impact on performing daily activities -that information technologies are used to perform-more effectively (Lee, Mauriello, Ahn, & Bederson, 2014). In this context, it can be said that the acquisition of CT skills during education and training process and the determination of the factors that are effective in the skill acquisition process have a great importance. When the literature has been examined, it has been seen that there are gaps related to this subject. From this point of view, the focus of this study is on the impact of various factors at the K5-12 level on the CT skill level.

1.1. What is CT? definition and scope

The concept of 'computational thinking' has become popular with the view that claimed by Wing (2006) which is "computational thinking represents applicable attitude and skill set for everyone, not just computer scientists". However, there is still no consensus on the definition of the concept of computational thinking, and discussions on this definition process are still in progress (Barr & Stephenson, 2011; Brennan & Resnick, 2012; Grover & Pea, 2013). Wing (2014) refers to the concept of computational thinking as an abbreviation for thinking like a computer scientist in the face of problems. In this context, Wing (2006) for the first time identified CT in 2006 as a thinking set that includes understanding problems with appropriate presentation styles, rationalizing these issues through abstraction and developing automated solutions for them.

Later on Wing (2014) have developed this definition and expressed CT as a thinking process that includes the formulation of problems as a computer can effectively perform and expression of the solutions/solutions. In another definition, Kalelioğlu (2015) defined the skill of computational thinking by using the mental abilities of; ability of individuals to generalize problem solving process in accordance with the information processing processes to other problems, automating the solution processes by thinking algorithmically, transforming the information by organizing and analyzing, abstracting information through computer applications, ability to use abstraction and modelling skills consecutively.

ISTE and CSTA (2011) defines computational thinking skill as a reflection of algorithmic thinking, creative, logical thinking and problem solving skills. NRC (2012) suggests mathematics and computational thinking as main practices within K-12 science education. Considering these definitions, the relation of computational thinking skill with numerous variables is communicable. A descriptive list of computational thinking characteristics determined by the ISTE together with CSTA is presented in Fig. 1 (ISTE & CSTA, 2011).

Although there are different efforts to define the term and there is no consensus on different definitions, there is a general acceptance that CT skills cover the concepts of "abstraction, algorithmic thinking, problem-solving, decomposition, generalization, and debugging" (Sarıtepeci & Durak, 2017). In support of this, Kalelioğlu, Gülbahar and Kukul (2016) have formed a word cloud in relation to the explanations about computational thinking in their work and have found that the data words that are most used in terms of defining the process of computation thinking in the literature are "abstraction, problem, solving, algorithmic and thinking.

1.2. The role of gender and educational level variables in CT skills

It can be said that gender and education level are two of the variables that should be taken into account in terms of acquiring and developing CT skills. It can be said that there is a conviction that the gender factor is effective in regards to the development of the CT skills, which is used as a concept related to general computer science. It can be argued that the most remarkable reason that constitutes this conviction is the influence of gender roles on attitudes towards technology (Stein & Nickerson, 2004). The concept of technology mentioned in this context generally corresponds to programming activities

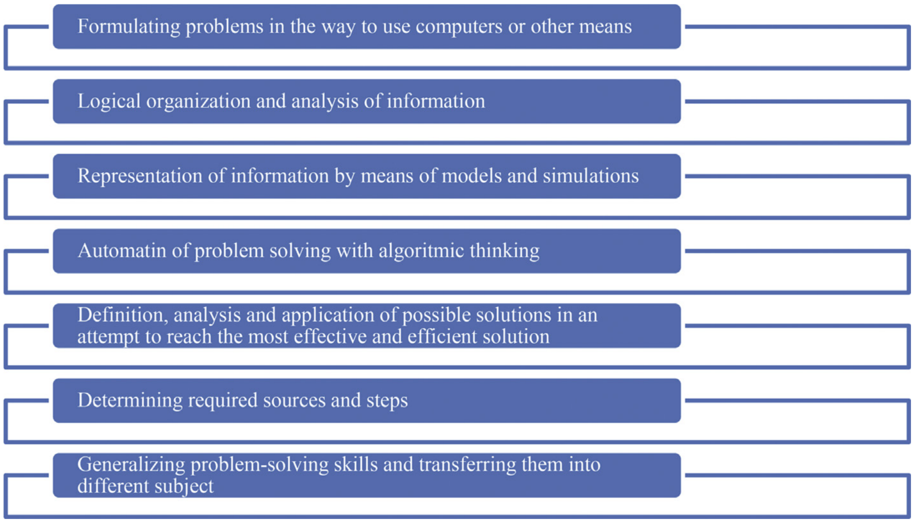

Fig. 1. Characteristics of computational thinking.

(algorithm, block-based coding, robotic). Because there are many studies in the literature that demonstrate a significant relationship between programming self-efficacy levels, CT skill levels and development of this skill (Lee, Martin & Apone, 2014; Sarıtepeci & Durak, 2017). There are a number of studies investigating the relationship between gender and self-efficacy or the changes in programming competencies in the process of coding, programming or robotic teaching (Askar & Davenport, 2009; Crews & Butterfield, 2003).

Several studies have demonstrated that there is no significant relationship between CT skill levels and gender (Werner, Denner, Campe, & Kawamoto, 2012); on the other hand, some studies have shown that gender has an impact on CT skills (Román-González, Pérez-González, & Jiménez-Fernández, 2017). In one of these studies, Atmatzidou and Demetriadis (2016) have found that the level of CT skills does not differ according to age and gender. However, in the same study, it has been determined that particularly female students put more effort and time to achieve CT skills similar to male students. On the other hand, Román-González et al. (2017) have found through the study conducted with the participation of 5–12 grade students that the computational thinking skills differ according to the gender, in favor of male students. According to the research, even there are difference according to sex in 7th-8th and 9th-10th grades, there is no significant difference in terms of scores of male students in the 5–6 grades even though they have high scores. The general studies conducted in support of these findings reveal that male students are more likely to develop programming skills in comparison to female students (Kiss, 2010) and are more interested in programming. However, the situation at the K6 level is different and the effect of the gender variable on the programming and programming skills remains at a limited level (Kalelioğlu, 2015).

In this study, participants distributed between 5th-12th grades in terms of educational levels. Although it is expected that the level of CT skill will increase with the level of education, it can be said that the trainings to acquire and develop CT skills may also play a decisive role. The fact that CT skills are expressed as a reflection of skills associated with cognitive development, such as abstract thinking, problem-solving, critical thinking, and algorithmic thinking skills, reinforces the belief that there may be a relationship between grade levels and CT skill levels (Basogain, Olabe, Olabe, Maiz, & Castaño, 2012; Binkley et al., 2012; Grover & Pea, 2013). In relation to this, Román-González et al. (2017) have found that there is a positive correlation between grade levels and CT skills through a study that examines the relationship between grade levels and CT skill levels. This finding also supports the assumption that CT skills are problem-solving skills. In addition, it has been emphasized that the level of cognitive development and level of maturity are important factors in terms of the development of CT skills as well as in problem-solving skills (Román-González et al., 2017).

Starting to the process of teaching computational thinking skills is considered as a challenging stage for learner regardless of sex, age (grade). However, a problem in teaching the skills within the computational thinking in this line is determining differences in levels of effect of grade level and sex on skills such as abstraction and analysis (Atmatzidou & Demetriadis, 2016; Alimisis, 2009; Barr & Stephenson, 2011; Lee, Martin, Denner, and oth, 2011; National Research Council [NRC], 2010). Research hypotheses related to these topics are given below:

H1. Sexes of students have a positive effect on their computational thinking skill levels.

H2. Education levels of students have a positive effect on their computational thinking skill levels

1.3. The role of CT usage status (experience, daily use) in CT skills

Computer science has been recognized as an important thematic area in teaching computational thinking skills (Pellas & Peroutseas, 2016). ISTE and NRC argue that students can demonstrate computational thinking skills even though they do not perform creative practices by using technological tools. In other words, it has been emphasized that the interaction of the students with the technology is considered important in terms of reflection of the computational thinking skills. In this context, it can be said that the experiences of individuals on the use of ICT may also have an effect on the level of computational thinking skills. In particular, there is a broad consensus on the importance of programming education in terms of teaching and improvement of computational thinking skills (Koorsse, Cilliers, & Calitz, 2015; Lye & Koh, 2014; Sariterepeci & Durak, 2017). A number of studies have been suggested that programming involves presenting the designed products and the computational thinking skills (Kafai & Burke, 2013; Resnick et al., 2009). Research hypotheses on these issues are given below:

H3. Students' experience of using IT has a positive effect on their computational thinking skill levels.

H4. Students' daily period of using the Internet has a positive effect on their computational thinking skill levels.

1.4. Academic achievement in mathematics and science in CT skills and the role of attitude towards these courses

Computational thinking is a concept related to science and mathematics besides computer science which that has origins in past even though it has been introduced conceptually by Wing in 2006 (Bundy, 2007). In other words, while the concept of computational thinking has been using the basic concepts for, information processing and computer science, it has an important role in developing skills commonly used in mathematics and science such as problem solving, abstraction, algorithmic thinking, creative thinking, logical thinking, analytical thinking (Barr & Stephenson, 2011).

Indeed, many examples or definitions show that computational thinking can be applied to the fields of Mathematics and Science and integration can be realized (National Governors Association [NGA], 2010). According to Perkins and Simmons (1988), there are common roots in learning similar concepts, scientific reasoning, learning difficulties and similar skills in terms of the fields of mathematics, science, computer science and programming (eg definition of a problem, analysis of a problem, problem-solving, and difficulties related to problem-solving). On the other hand, Harel and Papert (1991, pp. 51–52) argue that computer science is in interaction with other fields at a high level. Similarly, it has been emphasized in different studies that sub-skills of computational thinking can be effective tools to learn concepts of science and mathematics (eg algorithmic thinking, critical thinking etc.) (Blikstein & Wilensky, 2009; Hambrusch, Hoffmann, Korb, Haugan, & Hosking, 2009; Kynigos, 2007). At this point, it can be said that science and mathematics teaching in K12 can support each other synergistically.

On the other hand, there are no studies in the literature on the question of whether the positive attitudes of students towards Mathematics and Science course are important in terms of the development of CT skills. However, it can be said that there is a significant relationship between the effective characteristics of the students and the success on the course (Tan, 2006; Tobias, 1993). For that matter, the achievement reached during the teaching process is achieved through attitudes and values beyond the knowledge and skills (Fidan, 1996). Attitude is an indicator of the tendency of the individual to wish and enjoy his/her duties towards the relevant lesson course is also associated with success (Johnson, 2000; Tapia & Marsh, 2000; Yilmaz, Akbaba-Altun & Olkun, 2010). There are studies in the literature which show that attitude towards mathematics is one of the important variables explaining the mathematical success (Johnson, 2000; Ma, 1997; Peker & Mirasyedioğlu, 2003). Similarly, it has been determined that as the positive attitude towards the science course increases, the success in science has also been increased (Alomar, 2006; Anıl, 2010). In this study, the relationship between CT and the positive affective characteristics developed towards the courses of Mathematics and Science has been discussed.

Research hypotheses related to these topics are given below:

H5. Students' success in maths class positively affects their computational thinking skill levels.

H6. Students' attitude towards maths class positively affects their computational thinking skill levels.

H7. Students' success in Science class positively affects their computational thinking skill levels.

H8. Students' attitude towards Science class positively affects their computational thinking skill levels.

1.5. Academic achievement in the information technologies course in terms of CT skills and role of attitude toward the course

The concepts and applications of computational thinking are based on concepts that are fundamental to computer and computer science (Korkmaz, Çakir, & Özden, 2017; Wing, 2008). This skill includes epistemic and application-based knowledge structures related to computer science such as problem-solving, presentation of the problem, abstraction, analysis, verification and reflection through information technologies (Wing, 2008). According to the NGA (2010), computational thinking is a general analytical approach in order to understand problem solving and designing computer systems. CT uses basic concepts and topics related to computer science (Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013). From this point of view, it can be said that the applications created for learning CT skills must be designed in a way that is interwoven with computer science. For example, it can be said that programming in the K-12 has an organic relation with learning the working system of computer systems, and topics related to computer science may constitute effective tools in learning CT. In particular, there is a broad consensus on the importance of programming education in terms of teaching computational thinking (Koorsse et al., 2015; Lye & Koh, 2014). In some research studies, it has been suggested that the presentation of computational thinking skills has been provided through the interest in computer science in K-12 and with designed products (Kafai & Burke, 2013; Resnick et al., 2009).

From this point, following hypotheses have been established in the study.

H9. Students' success in Information technologies class positively affects their computational thinking skill levels.

H10. Students' attitude towards Information Technologies class positively affects their computational thinking skill levels.

1.6. The role of thinking styles of students in terms of CT skills

Thinking styles are the ways related performance of skill, knowledge, abilities to in which individuals prefer to use while finding a solution (Sternberg & Grigorenko, 1997). Based on Sternberg and Grigorenko's (1997) Mental Self-Government Theory, an individual creates the resources, determines his/her boundaries and priorities, be in need of managing his/her own actions and activities and resist/adapt to changes according to the thinking styles based on individuals preference on how to think on a particular subject. In this framework, individuals organize their thoughts and actions in accordance with internal and external needs.

Today, it is mentioned that there are a number of thinking skills that students have to acquire in the 21st century society (Kalelioglu & Gülbahar, 2014; Partnership for 21st Century Skills, 2007). From the definitions and applications of CT, which is one of these thinking skills and becoming popular in educational research, it appears that CT expresses many sets of skills such as problem-solving, reflective thinking, algorithmic thinking, and analytical thinking (Wing, 2008). According to Barr, Harrison, and Conery (2011), what differentiates computational thinking from critical, mathematical or algorithmic thinking is the new and powerful combination that CT creates by using different thinking skills in terms of problem-solving. Thus, it can be expected that different components to come together with CT and form a thinking system. It has been thought that how learners think in this thinking system is an important component in terms of acquiring the knowledge of computational thinking.

This is because the emergence and development of thinking styles in a learning environment where the individual can effectively acquire 21st century qualifications are important in terms of developing skills related to creative thinking, decision making, problem-solving, assessment and reasoning. (Sternberg & Grigorenko, 1997). In accordance with the students' thinking styles, it is possible to provide easier and more permanent learning of computational thinking through the planned activities directed towards computational thinking skills. In this regard, the study hypotheses regarding CT have been presented below:

H11. Students' ways of thinking have a positive effect on their computational thinking skill levels.

1.7. The objective of the research

The objective of this research is to determine how much the level of students' computational thinking skills is explained by variables of "sex, age, computer usage period, internet usage period, daily internet usage period, attitude against maths, point average in maths, attitude against science class, point average in science class, attitude against information technologies class, point average in information technologies class". Existence of relations between students' computational thinking skills and various variables were questioned and it was tested whether these variables predict their computational thinking skills levels. Additionally, it was aimed to produce a model that explains and predicts the relations between computational thinking skills and various variables. The research question within the scope of research objective was stated as "What is the explanatory and predictor relations pattern between students' computational thinking skill levels and various variables?"

2. Method

In this research, it was aimed to question the existence of relations between students' computational thinking skills and various variables and test whether these variables predict their computational thinking skills levels and then produce a model that explains and predicts the relations between computational thinking skills and various variables. Therefore, this research has relational screening model (Karasar, 2005).

2.1. Research model and hypotheses

Research model was created in accordance with the body of literature. In this model, research hypotheses are indicated with one-way arrows between the variables. Fig. 2 displays research's hypothesis pattern.

The hypotheses determined in relation to the research are:

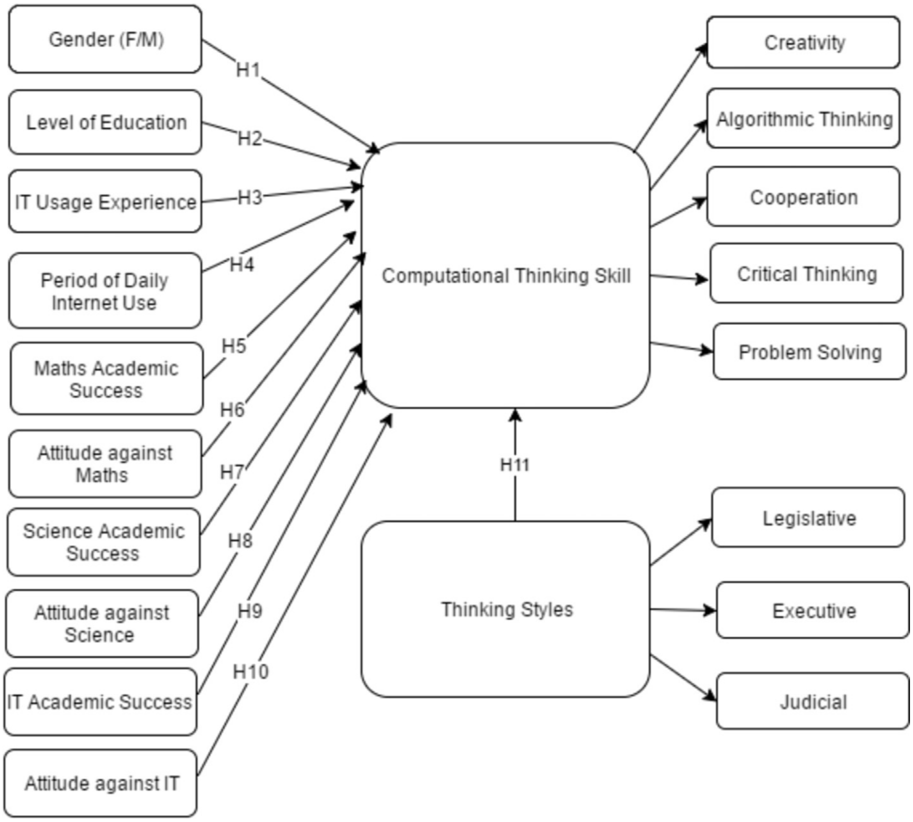

Fig. 2. Hypotheses-based default research model.

H1 Sexes of students have a positive effect on their computational thinking skill levels.
H2 Education levels of students have a positive effect on their computational thinking skill levels.
H3 Students' experience of using IT has a positive effect on their computational thinking skill levels.
H4 Students' daily period of using the Internet has a positive effect on their computational thinking skill levels.
H5 Students' success in maths class positively affects their computational thinking skill levels.
H6 Students' attitude towards maths class positively affects their computational thinking skill levels.
H7 Students' success in Science class positively affects their computational thinking skill levels.
H8 Students' attitude towards science class positively affects their computational thinking skill levels.
H9 Students' success in Information technologies class positively affects their computational thinking skill levels.
H10 Students' attitude towards information technologies class positively affects their computational thinking skill levels.
H11 Students' ways of thinking have a positive effect on their computational thinking skill levels.

2.2. Study group and its characteristics

Study group of the research consists of 152 students having studied in 2015–2016 academic year in secondary school (5, 6, 7, 8 grades) and highschool (9, 10, 11 and 12 grades) levels. Study group consists of students, who voluntarily participated in the research from the schools which the researcher could personally access and were selected by suitable/convenient sampling method. 45,4% of participants were women, 54,6% were men. In terms of the level of education, 21,7% of them were secondary school students and 78,3% were high school students.

2.3. Data collection instruments

Three different data collection tools were used in the research. The first is "Personal Information Form Questionnaire", the second is "Computational Thinking Skills Scale" and the third is "Thinking Ways Scale".

Personal Information Form Questionnaire was developed by the researchers. With this data collection tool consisting of 18 items, the data were collected in regard to participants' personal information, situation of access to information technologies and use of these technologies, academic successes in maths, science and information technologies and attitude towards these classes. Questionnaire items differ basing on questions and are generally of likert nature.

The second data collection tool used in the research is "Computational Thinking Scale". This scale was developed by Korkmaz, Çakır, and Özden (2015). Original form of this scale aims at university students; in this research, it consists of 29 items and five factors in total. Its adaptation to secondary schools was conducted by Korkmaz et al. (2015). The number of items was reduced to 22 in this adapted scale of five-point likert type. In this scale that consists of five factors, "Creativity" sub-dimension consists of 8 items, "Algorithmic Thinking" sub-dimension consists of 6 items, "Cooperation" sub-dimension consists of 4 items, "Critical Thinking" sub-dimension consists of 5 items and "Problem Solving" sub-dimension consists of 6 items. Cronbach alpha consistency coefficient calculated for the scale in this research is at a high level (,916).

The third data collection tool used in the research is "Ways of Thinking Scale". This scale was developed by Sternberg and Wagner (1992) and adapted into Turkish by Fer (2005) (see Table 1). The scale aims to reveal dominant way of thinking with 13 thinking ways and 104 items all included under five main dimensions. The part consisting of 13 items was used in this research which was within legislative, executive and judicial factors, which were included in functions dimension of ways of thinking scale. This likert type scale, originally consisting of 104 items, was found too long for secondary school and high school level; therefore, Yıldız (2010) adapted this scale into the relevant education level. Therefore, Yıldız (2010) carried out validity and reliability works for the scale at a similar level of education for this part. Cronbach alpha consistency coefficient calculated in this research is, 899.

2.4. Data collection

Data collection tools were applied to the study group by means of the online-created questionnaire in the study. Students were handed in an instruction explaining the objective of the research before application of the data collection tool. Participants who volunteered in the study were not asked to provide any personal information such as name, student number etc. so that they could answer honestly. It was allocated 30 min for the practice to the participants.

2.5. Data analysis

In this research, Structural Equation Model (SEM) was used to question the existence of relations between students' computational thinking skills and various variables and test whether these variables predict their computational thinking skills levels and then produce a model that explains and predicts the relations between computational thinking skills and various variables.

The variables observed in this study were predicted and a model was created by means of LISREL 8.51 program. In order to reveal compatibility level of relation patterns in recommended model, χ^2 (chi-square fit index test), RMSEA (the root mean square error of approximation), GFI (goodness of fit index) CFI (comparative factor index), NFI (normed fit index) fit index tests were used and reviewed.

Table 1
Sub-dimensions and explanations of ways of thinking scale.

I. Functions
1. Legislative: Innovative, creative, ideogenetic
2. Executive: Compatible, organized, following instructions.
3. Judicial: judging, evaluating, stating opinions
II. Forms
4. Monarchic: Focusing on single objective and work at a time.
5. Hierarchic: Doing multiple works at the same time by prioritizing
6. Oligarchic: Doing multiple works at the same time without the ability of prioritizing
7. Anarchic: Randomly approaching to works, avoiding systems
III. Levels
8. Global: Dealing abstract thoughts, general frame
9. Local: Dealing concrete thoughts, details
IV. Scope
10. Internal: Independent, self-sufficient, communication-avoider
11. External: Working in cooperation, social, dependent
V. Leanings
12. Liberal: Innovator, unorthodox, dreamer.
13. Conservative: Traditional, orthodox, realist.

Source: Quoted from Sternberg and Grigorenko (1997); Fer (2005).

3. Findings and comments

Fig. 3 displays coefficients of structural equation model which was constituted by variables selected in line with the data obtained as a result of data collection tools applied to students. Before determining correlations with structural equation model, it is necessary to test fit indexes of measuring models with latent variables. Furthermore, it is also possible to analyse all the models with a single model in structural equation model. Fit ranges of goodness of fit criteria and the values obtained in the study were presented in Table 2.

0,10 of RMSEA value. Value acquired indicates an acceptable fit. Similarly, NFI being 0,94, NNFI 0,97 and GFI 0,93 indicate that the model presents an acceptable fit. Moreover, it was found that fit indexes of the model were significant by the level of 0,05 (chi-square, RMSEA, NNFI, NFI, CFI and GFI). It has been understood that according to the calculated values of the fit indices that are examined to determine the level of competence of the structural equality model that has been formed are at good and acceptable levels (Bentler, 1980; Browne & Cudeck, 1992). Accordingly, it has been seen that there is an acceptable rapport between the data and the structural equality model which is aimed to determine the level and direction of the relations between computational thinking and the elements that affect it. It has been understood that the compliance indices examined to determine the adequacy level of the constructed structural equation model are in good agreement with the calculated values (Bentler, 1980; Browne & Cudeck, 1992). Accordingly, it is seen that there is an acceptable agreement between the data and the structural equality model which is aimed to determine the level and direction of the relations between the informatics thinking and the elements affecting it.

When the structural equation model was analysed according to Fig. 3, "Computational thinking skill" was determined as latent variable. Model fit indexes were chi-square (495,23; p = ,000) significant.

When the variables concerning students' computational skill were analysed, it was found that "ways of thinking" was the most significant variable with the highest correlation coefficient ($\gamma = 0{,}89$) and then the variable "maths academic success" ($\gamma = 0{,}25$). Another variable deemed significant is "maths class attitude" ($\gamma = 0{,}21$).

Computational thinking skill latent variables have 5 sub-dimensions. "Creativity" sub-dimension among them has the highest factor load. Ways of thinking variable consists of 3 sub-dimensions and the highest factor load is within legislative way of thinking sub-dimension.

Considering relation coefficients, relative significance sequence of predictor variables over the level of computational thinking skill is as "ways of thinking, maths class academic success, attitude against maths class, level of education, science

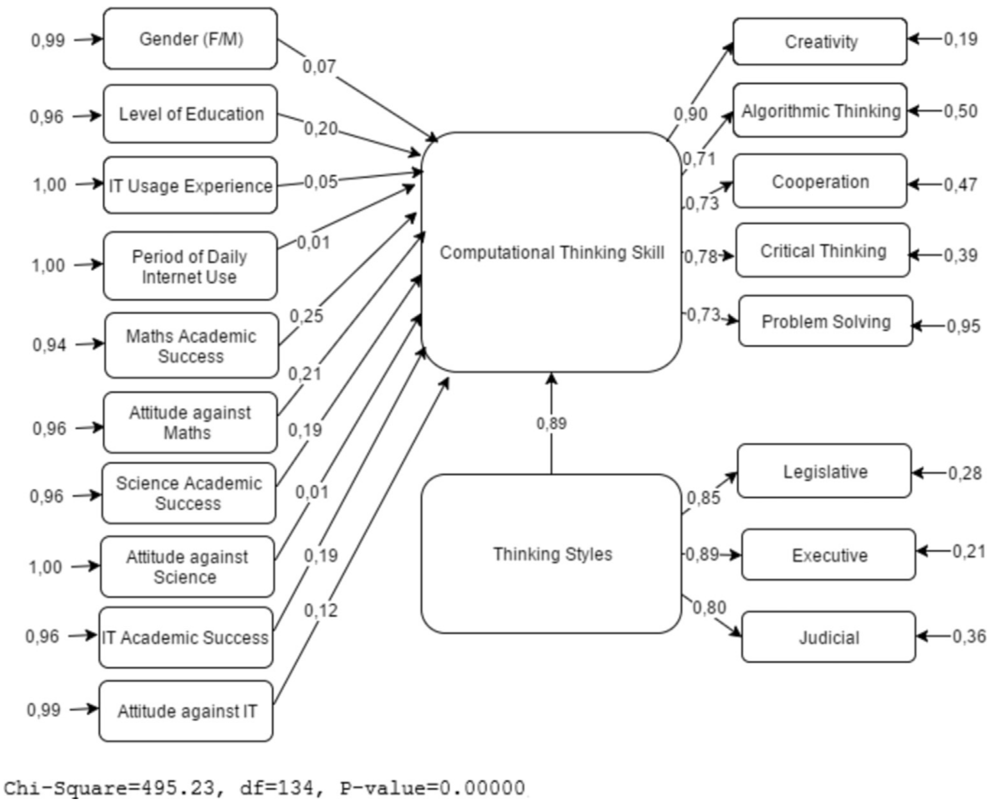

Fig. 3. Standard coefficients of structural equation model.

Table 2
Values of goodness of fit index in structural equation model.

Fit Values	Good Fit Values	Acceptable Fit Values	Values Reached
RMSEA	0 < RMSEA<0,05	0,05 < RMSEA<0,10	0.09
NFI	0,95 ≤ NFI ≤1	0,90 ≤ NFI ≤0,95	0.94
NNFI	0,97 ≤ NNFI ≤1	0,95 ≤ NNFI ≤0,97	0.97
GFI	0,95 ≤ GFI ≤1	0,90 ≤ GFI ≤0,95	0.93
CFI	0,97 ≤ CFI ≤1	0,95 ≤ CFI ≤0,97	0.98

class academic success, information technologies academic success, attitude against information technologies class, sex, IT usage experience, period of daily internet use and attitude against science class".

As it can be reviewed in Table 3, it was found that variance value (var = 1,29) of the variable of attitude against maths class was the highest, and variance value (var = 0,17) of the variable of education levels was found the lowest. Moreover, considering covariance values between variables, it was found that the highest values (cov = 0,38) were between attitude against maths class and maths class academic success and the lowest values (cov = −0,12) were between the period of daily internet use and maths class academic success.

According to Table 4; H2: "Education levels of students have a positive effect on their computational thinking skill levels" hypothesis was accepted (β = −0,325; p < 0,05, t = −3514). Accordingly, it can be said that the increase in the level of education at k12 level has parallels with the computational thinking skill level in general. Thus, it can be argued that cognitive development is an important factor in the development of CT skills (Román-González et al., 2017).

H5: "Students' success in maths class positively affect their computational thinking skill levels". Hypothesis was accepted (β = 0,142; p < 0,05, t = 1627). Accordingly, it can be expected that individuals who succeeded in mathematics course have a higher level of computational thinking skills than those who have a lower mathematical achievement. This situation can be explained by the fact that computational thinking structure requires mathematical thinking. At this point, Wing (2008) supports this finding by describing computational thinking as a concept that involves mathematical, engineering and scientific thinking.

H7: "H 7. Students' success in Science class positively affects their computational thinking skill levels" hypothesis was accepted (β = 0,158; p < 0,05, t = 1936). Accordingly, it can be said that there is a positive relationship between the achievements of participant students in the science courses with the level of computational thinking skills. In this context, NRC (2012) emphasizes that one of the most basic applications in the scope of science education is computational thinking and the other is mathematics education. Accordingly, it can be expected that the trainings carried out within the scope of science education have a structure that supports the development of the learners' computational thinking skills.

Table 3
Covariance matrix.

	1	2	3	4	5	6	7	8	9	10
Sex (M/F)	0.25									
Levels of Education	−0.03	0.17								
IT usage experience	0.08	0.10	0.81							
Period of daily internet use	0.14	−0.11	0.16	1.10						
Maths class academic success	−0.01	−0.01	0.08	−0.12	0.61					
Attitude against maths class	0.00	−0.15	−0.02	−0.16	0.38	1.29				
Science class academic success	−0.01	0.01	0.03	−0.01	0.15	0.09	0.36			
Attitude against science class	−0.11	0.02	−0.02	−0.09	0.09	0.22	0.15	0.63		
Information technologies class academic success	0.07	−0.09	0.01	0.14	0.07	0.11	0.07	0.04	0.54	
Attitude against information technologies class	−0.01	−0.07	0.08	−0.08	0.03	0.24	0.01	0.11	0.12	0.74

Table 4
Hypothesis Acceptance/Rejection table.

	Way/Relation	β- coefficient	t-value	Acceptance -/Rejection
H1	Sex –computational thinking skill	0.104	1.284	Rejection
H2	Education levels –computational thinking skill	−0.325	−3.514	Acceptance
H3	IT usage period –computational thinking skill	0.029	,344	Rejection
H4	Daily period of internet use –computational thinking skill	−0.008	-,096	Rejection
H5	Maths class academic success –computational thinking skill	0.142	1.627	Acceptance
H6	Attitude against maths class –computational thinking skill	0.058	,634	Rejection
H7	Science Class academic success –computational thinking skill	0.158	1.936	Acceptance
H8	Attitude against science class –computational thinking skill	−0.087	−1.041	Rejection
H9	Information technologies class academic success–computational thinking skill	0.050	,616	Rejection
H10	Attitude against information technologies class –computational thinking skill	0.071	,885	Rejection
H11	Ways of thinking –computational thinking skill	0.704	12.150	Acceptance

H11: "Students' ways of thinking have a positive effect on their computational thinking skill levels" hypothesis was accepted ($\beta = 0{,}704$; $p > 0{,}05$, $t = 12{,}150$). Accordingly, the effect of thinking styles on computational thinking skills has been realized at the highest level in comparison to the other variables. In addition, the thinking style scale consists of three sub-dimensions and it has been determined that there is a positive relationship between each sub-dimension and computational thinking.

H1, H3, H4, H6, H8, H9, H10 hypotheses which are related to; gender, experience in information technology usage, daily internet use, attitude towards the mathematics course, attitude towards the science course, academic success information technologies course and attitude towards the information technologies course have been rejected.

4. Results, discussion and recommendations

According to model analysis findings, it was established that ways of thinking directly affected computational thinking. It was found that computational thinking was highly predicted by variables of "ways of thinking, maths class academic success, attitude against maths class, level of education, science class academic success, information technologies academic success, attitude against information technologies class, sex, IT usage experience, period of daily internet use and attitude against science class". According to these findings, it was determined that the most effective variable in predicting computational thinking in the valid model was ways of thinking.

Findings display parallelism with research findings in the literature. For instance, in doctoral thesis, Prottsman (2011) emphasized that there was a relation between sex and computational thinking and women were more talented in computer science and acquiring computational thinking skills.

For it was established in this study that ways of thinking were significant factors predicting computational thinking skills, it was thought that learners' knowing and using ways of thinking and having this certain awareness would make them more successful in acquiring computational skills. According to Cohen (1998), learning ways of thinking will enhance students' creative learning skill and result in increase of their skills such as problem solving and abstraction. It is thought that instructors or teachers will support learners' exploration of ways of thinking to this end.

Another finding of modelling study was that education levels negatively predicted computational thinking skill. In other words, it was established that level of education had a negative value in predicting computational thinking level. Concordantly, the fact that this relation is negative-oriented might mean that computational thinking skills of high school students will be negatively affected as their level of education increases. It could be an explanation that students did not receive information technologies class because it was an elective course for a while in Turkey but it became a compulsory class again in 2013 in secondary schools and programming teaching became prevalent in this class. Moreover, this finding overlaps with many studies which pointed out the significance of studies to teach computational thinking skills and programming in early ages (Akçay, 2009; Burke & Kafai, 2010;Kalelioglu & Gülbahar, 2014; Kazakoff, 2015; Maloney, Peppler, Kafai, Resnick, & Rusk, 2008; Shin, Park, & Bae, 2013)

On the other hand, the effect of the attitude against maths class and maths class academic success on computational thinking skills is of significance. There are certain researches in the literature on this subject (Akçay, 2009; Burke & Kafai, 2010; Kalelioglu & Gülbahar, 2014; Kazakoff, 2015; Maloney et al., 2008; Shin et al., 2013)

For future studies, it is recommended that curriculums are reviewed basing on learners' ways of thinking in design studies of learning environments, which will teach computational thinking skills, by considering the valid model, and effects of these curriculums are researched.

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