

Highlights

► We aimed to develop computational thinking scale. ► A 29 item computational thinking scale was composed. ► Five factor were emerged for computational thinking scale ► Factors are termed Creativity, Cooperativity, Algorithmic- Critical Thinking and Problem Solving ► Reliability and validity of the scales are psychometrically good.

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A validity and reliability study of the Computational Thinking Scales (CTS)

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It is possible to define Computational Thinking briefly as having the knowledge, skill and attitudes necessary to be able to use the computers in the solution of the life problems for production purposes. In this study, a scale has been developed for the purpose of determining the levels of computational thinking skills (CTS) of the students. CTS is a five-point likert type scale and consists of 29 items that could be collected under five factors. The study group of this work consists of 726 students educated at the levels of associate degree and undergraduate degree with formal education in Amasya University for the first application. For the second application 580 students who were educated in pedagogical formation education via distance education in Amasya University. The validity and reliability of the scale have been studied by conducting exploratory factor analysis, confirmatory factor analysis, item distinctiveness analyses, internal consistency coefficients and constancy analyses. As a result of the conducted analyses, it has been concluded that the scale is a valid and reliable measurement tool that could measure the computational thinking skills of the students. In addition; the digital age individuals are expected to have the computational thinking skill, and at what degree they have these skills, the revelation of whether the levels they have are sufficient or not are a

requirement. Within this frame, it could be said that the scale could make significant contributions to the literature.

Key Words: Computer-mediated communication; valuation methodologies; pedagogical issues; programming and programming languages; teaching/learning strategies

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1. Introduction

It is possible to define Computational Thinking briefly as having the knowledge, skill and attitudes necessary to be able to use the computers in the solution of the life problems for production purposes (Özden, 2015). Computational thinking is a method of problem solving, system designing and also a method of

understanding the human behaviors by drawing attention to the basic concepts of the science of computer. Computational thinking also covers the acquainted concepts such as analysis, data demonstration and modeling and also the ideas that are less known such as binary search, repetition and parallelization. When the fact that computational thinking has a border and general frame is taken into consideration, it is a valid basic skill not only for the computers, but also for everybody and it is considered that it shall take place in the basic skills (reading, writing and arithmetic) used by everyone in the near future (Wing 2006). Computational thinking is a fundamental skill for everyone, not just for computer scientists. Wing (2006) emphasizes that computational thinking should also be added to the reading, writing and arithmetical processes for the analytical skills of every child. According to the researchers (Wing, 2006); the computational thinking makes use of extraction and decomposition when it is compared to the great complex systems or processes. It helps in the selection of a convenient representation to solve a problem or modeling in the parts related to the problem. Moreover; the digital age individuals are expected to have the computational thinking skill, but no proof has been encountered in the literature regarding at what degree they have these skills and the revelation of whether the levels they have are sufficient. Within this frame, it could be said that the scale could make significant contributions to the literature.

According to Bundy (2007), computational thinking affects the studies in almost all the disciplines in both the human sciences and the natural sciences. The researchers make use of the cognitive metaphors for the purpose of enriching the theories such as protein science and mind-body problem. The science of computer has made the researchers gain the skills of asking new questions such as the ones requiring the data process with substantial amount and forming new solutions.

Today, there is almost no environment in which there is no computer and no computer is used. The daily usage is mostly limited to communication, surfing in the Internet or office applications. Whereas, the concept of computational thinking is far deeper than them and forces the ordinary thinking way to change. Such that, it is claimed that a person who would like to understand the 21st century is firstly obliged to understand the computational thinking (Bundy, 2007).

On the basis of the aforementioned explanations, there are limited numbers of studies in the literature regarding this skill that has such an important for the individuals to have for meeting the requirements of the digital age. Moreover; the digital age individuals are expected to have the computational thinking skill, but no proof has been encountered in the literature regarding the determination of at what degree they have these skills and the revelation of whether the levels they have are sufficient. Within this frame, it could be said that the scale could make significant contributions to the literature.

Wing (2008) argued that CT complements thinking in mathematics and engineering with a focus on designing systems that help to solve complex problems humans face (Wing 2008; Lu and Fletscher 2009). The core CT concepts include, abstractions (the mental tools of computing, necessary to solve the problem), layers (problems need to be solved on different levels) and relationships between layers and abstractions (Wing 2008). The idea of abstraction and students' ability to deal with different levels of abstractions, as well as to think algorithmically and to understand the consequences of scale (big data), are fundamental to CT (Denning 2009; Lu and Fletscher 2009). Aho (2012) further argued that CT involves "thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms"

(p. 832). Denning (2009) argued CT has a long history in computer science dating back to 1950s when it was known as algorithmic thinking meaning “a mental orientation to formulating problems as conversions of some input to an output and looking for algorithms to perform the conversions” (p. 28). Some computer science educators have also argued that programming is not essential in the teaching of computational thinking (e.g. Yadav et al. 2011; Lu and Fletscher 2009). Lu and Fletscher (2009) even suggested that an emphasis on programming might deter students from becoming interested in computer science. In sum, computational thinking is a conceptual way to “systematically, correctly, and efficiently process information and tasks” to solve complex problems (Lu & Fletcher, p. 261).

Many educators and especially the experts in the educational technology field have emphasized that Computational thinking is so significant in terms of the skills of 21st century (VoogtFisser, Good, Mishra, &Yadav, 2015). When the definitions given in the literature are examined, the focus regarding the computational thinking is that it contains continuity by getting help from the computing and computers in the solution of the complex problems (e.g. Barr and Stephenson 2011; Grover and Pea 2013; Lee et al. 2011; Sengupta et al. 2013; Wolz et al. 2011), it is very distinguishing in many levels in the abstraction and design-oriented thinking (Sengupta et al. 2013) and it brings the algorithmic thinking to the forefront (Mishra and Yadav, 2013).

It is possible to see in the literature some scales that measure the sub-dimensions of the computational thinking skills as independent from one another (Korkmaz, 2012; Korkmaz&Yeşil, 2010; Aksoy, 2004; Kökdemir, 2003). This research is limited with self-report based scale and other assessment techniques were not taken into consideration. In this frame; in the literature, no scale whose validity and reliability

have been proven has been found to measure the levels regarding especially the computational thinking skills. The purpose of this study is to develop a scale for the purpose of determining the computational thinking skills of the students by filling this space in the literature. It is considered that this scale shall make significant to measure CT

2. Theoretical Framework

2.1. Computational Thinking

Even if the CT concept was used by Papert (1980) in the literature for the first time, the first description was done by Wing (2008) but it was not countervail the description fully. However, what the CT covers has been a subject of question.

Computational thinking that is a kind of analytical thinking according to Wing (2008) makes use of the common points with the mathematical thinking at the stage of problem solving, with the engineering while designing and assessing a complex system and with the scientific thinking in understanding the concepts such as calculability, mind, brain and human behaviors. According to ISTE (2015), this skill does not take the place of creativity, logical thinking and critical thinking; but it increases the capacity of a computer in the solution of a problem of a human being by taking benefit of the human creativity and critical thinking by putting these skills forth while revealing the problem solving ways in a way that the computers could help. Similarly, Curzon (2015) defines the computational thinking as a basic skill that comes to the meaning of problem solving for the human beings and points out that it is necessary to understand what the problem is before thinking of the solutions while solving a problem according to a certain point of view. **CT; Formulating problems, Logically organizing and analysing data, Representing data through abstractions such**

as models and simulations, Automating solutions through algorithmic thinking, Identifying, analysing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources and Generalizing and transferring this problem solving process to a wide variety of problems was defined as one of the processes to solve the problem that was arisen (CSTA & ISTE, 2011). But later on, ISTE (2015), computational thinking covers the skills of creativity, algorithmic thinking, critical thinking, problem solving, establishing communication and establishing cooperation (ISTE). Barr, Harrison and Conery (2011) emphasized that the computational thinking is a problem solving process including the following properties: The formulation of the problem in a way that computers or other tools can help for its solution; Arrangement and analysis of the data in a logical way; Presentation, modeling and simulation of the data by means of abstraction; Automation of the solutions with the help of algorithmic thinking; Application of the possible solutions; Conversion of the problem solving process into problem variability and extensification. Similarly, Google (2016) described the CT as a problem solving process that includes a number of characteristics and dispositions and it also expressed that the CT covers the skills such as Pattern Recognition, Abstraction and Algorithm Design.

Mannila et al.(2014), Riley and Hunt (2014) and Syslove and Kwiatkowska (2013) emphasized that the CT is a set of thinking skills. When considering that ISTE is a high level skill above the problem solving skill and the other skills and their subcomponents mentioned above, it can be said that ISTE (2015) is more convenient component than what the CT covers. For the purpose, in this research, the components of the ISTE discussed in detail below are accepted as straightforward.

According to ISTE (2015), as a requirement of the age of informatics, the computer people should learn where, how and when they shall make use of the digital tools for the solution of problem.

In addition, the conducted studies have expressed that the students of 21st century have the skills of novelty, creativity, research, cooperation, problem solving, critical thinking, technology, social skills, cognitive skills, communication skills and self-management skills (Günüç, Odabaşı&Kuzu,2013). In recent study; Anshari, Alas, Yunus, Sabtu & Hamid (2016) highlighted that students of 21st century generally use internet to access resources by using mobile devices instead of traditional techniques.

At the same time; it is also an important issue how to be in contact with the people who may be helpful in the computer-based solutions. The concept of computational thinking could be used to be able to explain these proficiencies as a whole. Because, the students develop their own thinking way when they realize that the computers could produce more effective automatical solutions while solving the problems. ISTE (2015) emphasizes that the purpose of computational thinking in education is not bringing the students to the position of leader in computer science, but applying their computational thinking skills in also other courses like a habit. While the most important skill owned by a human in problem solving is mind, the development of this skill by means of computer and other digital tools has become one of the basic parts of our work (Barr et.al., 2011). It is also possible to say that the students already learn some of the sub-structures of computational thinking in the contents of many different courses. According to Barr et.al. (2011), all the students should be sure that they have all the sub-elements belonging to the computational thinking and the ownership of these skills by the students and being able to transfer them to other

problem situations are seen as an important requirement.

In summary, according to ISTE (2015), computational thinking is the extension of the problem solving skills of a person and the development of the creativity and critical thinking skills of the people by re-focusing. The students make use of the computational thinking while using the algorithms to solve a problem and while solving the problem with calculation. The students establish connection with the computational thinking while analyzing a text or designing complex communications. In addition, they also make use of the computational thinking while analyzing very broad data groups and expressing the pattern of the study in the scientific researches. ISTE (2015) defines computational thinking as the common reflection of creativity, algorithmic thinking, critical thinking, problem solving, cooperative thinking and the communication skills. These skills are the ones that are mostly discussed in the literature. However; when these skills are taken into consideration as together, they explain a brand-new thinking skill that is called as computational thinking. When considered within this frame; it shall be beneficial to explain other skills used to define this thinking skill to be able to understand the computational thinking correctly. These skills could be shortly explained as follows:

2.2. Creativity:

Craft (2003) has explained creativity as a skill that is not related to art and that is life-long, and defined it as “the capacity of expressing oneself and using mind and imagination”. Creativity is a concept that has always been existent in the life of human being since the past and that covers the different viewpoints of the people. It literally means to generate and form. Creative thinking is one of the prominent concepts of our age. It has found a place for itself in many areas such as politics, economy, art, technology and science (Aksoy, 2004). At the same time, creativity is

the skill of being able to reveal a non-existent product, being able to imagine or being able to carry out a work in was different than those seen by everyone and being able to develop new ideas. Being able to find different solutions for the events and experiences faced in the daily life and having different viewpoints from those of others are related to the richness of the creativity side of a person. Creative thinking has a great importance in the developing societies. Gaining different viewpoints to this development by following the improving science and art is possible with creative thinking. According to Aksoy (2004); creativity is to reveal new relations and form new compositions from one or more concepts in the mind for the purpose of observing the events from new viewpoints. All the imagined things are the new compositions of ideas, products, colors and words. Creativity results in the scientific inventions, new products, art and literature meeting the needs of the humankind.

According to Cropley (1997) creative thinking has three basic elements.

- Novelty: It is a new product that is revealed as a result of an idea or a behavior that is separated from its likes with certain lines.
- Impressiveness: It could be a material that brings income or that is beneficial as well as it could be the aesthetic, artistic or divine things.
- Ethical Conformity: The term “creativity” is not used to define the selfishness, subversion, crime, agonizing things or pleasures.

Creative thinking is not a way of thinking all alone. It also covers the thinking structures inside itself such as critical problem solving. An individual having the property of creative thinking also has the properties of critical thinking and problem solving. Creative thinking starts with the self-recognition of a person. Developing genuine ideas different from the ordinary ones and finding these ways are the results

of the problem solving skill and creative thinking. As a summary, programming is a process that makes the problem numerical and helps realize the solution. In this context, the student discovers his creativity and finds methods for solution. Thus, it can be said that creativity is one of the important components of CT.

2.3. Algorithmic Thinking:

Algorithmic thinking is the skill of understanding, applying, assessing and producing the algorithms (Brown, 2015). When it is considered that the daily life is surrounded with the algorithms, it could be concluded that it shall be an important gain to develop this skill of the individuals. Algorithmic thinking is deemed as one of the key elements to be able to be an individual in line with the age of informatics defined by NRC (US National Research Council). According to NRC union; algorithmic thinking has been defined as follows, “General concept of algorithmic thinking covers the subjects of generalizing and parameterize the functional analysis, repetition, basic data organizations (record, order, listing) and the subjects of algorithm and program, upper and lower designs and correction. In addition; it is not specifically necessary to understand or make use of math in some algorithmic thinking types.” (Fluent 1999). It is necessary to have the skills of understanding and assessing the algorithms to be algorithmic thinker. While some people find it easy to reach the solutions by using certain instructions, others could define it as challenging. Because every step should be taken in the correct order and without any skipping, it could be said that algorithmic thinking is a process demanding patience. In addition to patience, an individual thinking algorithmically should be meticulous and determined. Therefore; many people give up without being able to complete the steps (Brown, 2015). Another requirement of algorithmic thinking is the skill of assessment. This also determines whether an algorithm shall really form a solution to a given problem.

The final requirement of algorithmic thinking is the skill of being able to produce new algorithms. It is a hard process in a given work to form a certain order and writing the step instructions that is always right. While it is easy to produce algorithms for easy problem statuses, the algorithm to be written gets complex as the problem status gets complex (Brown, 2015). Consequently; an individual that could think algorithmically could think in a detailed and purposeful way in the issue of the solution methods while producing a solution in any subject. As a result, solving a problem can be realized by placing the proceedings in sequence. For the purpose, it can be claimed that one of the important components of CT is Algorithmic Thinking.

2.4. Critical Thinking:

According to Halpern (1996); critical thinking has been defined as “the use of cognitive skills or strategies that increase the possibility of the desired behaviors”. When the literature is examined, it could be observed that one of the most criticized issues of our educational system is rote learning that is the result of the traditional understanding. The individuals that are not questioning shall be insufficient in meeting the desired qualified human power in the age of information in which there is always a change and development. The need for critical thinking occurs at this exact moment. Critical thinking is one of the subjects that catch the attention of the researchers recently. ÇoklukBökeoğlu and Yılmaz (2015) have expressed that the individuals to keep up with the change is possible by means of using the information efficiently as a result of the information explosion and they have emphasized that the individuals that are making efficient use of information are those that are flexible, creative, questioning, researching, analyzing, who could assess the events in many ways, who could make selections, who are open for innovations, who know themselves well, in other words, who could think critically. When the literature is

examined, it could be seen that there are many different definitions on the critical thinking. In the most general meaning, critical thinking is one of the high level thinking skills. Kazancı (1989) has expressed that critical thinking is the whole of the attitude, information and skill processes that are used in the justification and assessment of a problem status according to the scientific, cultural and social standard scales in terms of consistency and validity. Critical thinking could be defined as the active, regular and functional process that is carried out to be able to make better use of the understanding and presentation skills of the individual's or others' ideas and thoughts (Chaffe, 1994:imp. Kökdemir, 2003). According to Facione; critical thinking is to make a judgment and reach a decision within the direction of a purpose with the explanation of the proofs, concepts, methods, scales and contexts as well as the interpretation, analysis, assessment and conclusions (imp: Özdemir, 2005). Ennis (1985) has mentioned the three structures of critical thinking as the judgment, development of information and questioning, and has defined critical thinking as the reflective and logical thinking focused on deciding what shall be done and what shall be believed. Critical thinking has been seen as skill of the individual for determining the assumptions, hidden belief, values and attitudes. Smith has expressed that the critical thinking is the judgment focused on accepting or rejecting the claims. On the other hand; Paul has stated that critical thinking is the processes of an individual for shaping and assessing his/her own idea. According to Mayhew; critical thinking is the process of questioning "how" and "why" (Seferoğlu&Akbiyık, 2006). According to Kökdemir (2003); there are the skills such as being able to catch the difference between the reality and asserted claims, being able to test the reliabilities of the resources belonging to the attained information, being able to debug the unrelated information from the proofs, being aware of the prejudice and cognitive errors, being

aware of the inconsistent judgments, being able to ask efficient questions, being able to make efficient use of verbal and written language and meta-cognitions etc. in which the individual is aware of his/her own thoughts among the skills covered by the process of critical thinking. To be able to make an inter-disciplinary definition of critical thinking; in a study conducted by 46 theorists from the countries of the United States of America and Canada by American Psychology Association (APA) in 1990, critical thinking is defined as “the individual to make analyst and assessment-oriented conscious judgments and express these judgments to reach a decision as to that s/he shall do or believe” (Evancho, 2000). As a conclusion, a problem can be solved by using different methods; in another words, when a problem is solved through critical thinking, critical thinking can be considered as an important component in CT.

2.5. Problem Solving:

The obstacle on the way that someone finds to reach the intended purpose is called Problem. If someone meets with some obstacles while endeavoring to reach a certain purpose or intellection, it means there is a problem for that person (Aksoy, 2004). The word “problem” is the general name of many troubles we encounter in life. The difficulties, distress and hardships in social life are called problem. In the area of education, it is known as the problem to be intended to be found as numeral depending on some values and the solution for it (Aksoy, 2004). Overcoming the problems encountered in the future life is one of the priority targets of our education. The processes necessary for the solution stage of the problem should be gathered and used in the solution of the problem (Soylu&Soylu, 2006). When programming process is considered as a main problem solving process, problem solving skill cannot be ignored in a macro thinking skill such as CT.

2.6. Cooperativity:

Cooperative learning is a learning method in which learning of both individual and group members of the small groups are tried to be maximized (Veenman, Benthum, Bootsma, Dieren, & Kemp, 2002). ÇaycıBaşaran and Demir (2007) have defined the cooperative learning as rewarding the set success and set members helping each other to learn an academic subject with different methods by forming small sets in accordance with a common purpose. It has been known that cooperative learning is a method that is preferred and accepted as efficient in all levels (Johnson, Johnson, & Smith, 2007). Cooperative learning has a preferable place among the learning methods because of its contributions such as contribution to academic success, sharing information and establishing social relations (Korkmaz, 2012; Nam, 2014). That the individuals in the 21st century cooperating together for a deliberate purpose with different skills on solving complex problems is inevitable. In this context, cooperativity can be said to be one of the decisive skills of CT.

2.7. Communication Skills:

Human beings have tried to meet their needs of transmitting their feelings, thoughts, dreams and hopes by speaking and writing, tried to make them understandable by means of reading and writing and the phenomenon called as communication has occurred depending on this common sharing requirement (Çetinkaya, 2011). Communication in basic meaning could be defined as the feeling, thought and information sharing of the individuals with one another (Karatekin, Sönmez, & Kuş, 2012). Communication is a process that occurs with the two people sharing their feelings, thoughts and information to understand each other (Üstün, 2005). People get into communication and interaction with themselves and with their environment during their lives. There is a need for efficient communication skills to

express themselves, being able to impress their environment and being able to provide the changes they desire (Gökçe, AtanurBaşkan, 2012). Efficient communication skills could facilitate the human relations and professional relations(Korkut, 2005). It could be considered that people should establish communication to continue their lives and to interact with other people.

Consequently; based on the aforementioned skills and the approach of ISTE (2015), computational thinking could be defined as the skills of being able to develop creative solutions for the problem with an algorithmic approach by handling a problem by the individuals that could establish healthy communication in a cooperative environment. Within this frame; whether a person has computational thinking skills could be defined by examining the aforementioned skills. In CT, it is expected that the members of the project should communicate well when the cooperativity is desired to work to solve the problem. This communication can be provided based on the communication skills of the members. Hence, cooperativity can be accepted as one of the components of the CT. As a result, these mentioned sub-dimensions constitute CT. Each sub-dimension that constitutes CT covers the fundamental thinking and problem solving skills discussed for a long time. However, when these skills discussed one by one for years are gathered, they lead to new and more powerful skills. When CT is described, these skills that are in relation with each other directly are used. On the other hand, what CT is a new is a new concept discussed in field software. That is why, there are limited researches related to CT in literature.

2. Method

2.1. Sample

The sample group of this study consists of 726 students educated at the levels of associate degree and undergraduate degree with formal education in Amasya University, Turkey, in 2014-2015 spring term for the first application and 580 students educated in pedagogical formation education via distance education in Amasya University for the second application. The sample of this study was selected randomly from voluntary students. While other validity and reliability analyses have been carried out together with the exploratory factor analysis on the data collected with 1st Application, confirmatory factor analysis has been carried out on the data collected with the 2nd Application. The distribution of the study group according to their universities, classes and genders is summarized in Table 1.

(Insert Table 1)

2.2. Development process of the scale

The scale development process has started firstly by literature review and the formation of item pool. The item pool has been formed in 3 stages. At the first stage, the literature has been reviewed and the scales aiming to measure the similar properties have been examined. Although computational thinking is discussed in the literature within the scope of 21st century skills opened for discussion lately, this skill has been explained with 6 basic skills that have been clarified in details above by ISTE (2015). Within this frame; computational thinking has been defined by using these basic skills in this study.

Within this frame, suitable items have been selected from the Creativity scale called "How Creative Are You?" developed by Whetton and Cameron (2002) and adapted by Aksoy (2004) for the purpose of determining the creativity of the students

of the faculty of education, from “Problem Solving Scale” developed in 1982 by Heppner and Peterson and whose reliability study was conducted by Taylan (1990) for our country for the purpose of measuring the problem solving skills, from the “Cooperative Learning Attitude Scale” prepared by Korkmaz (2012), from “The Scale of California Critical Thinking Tendency” translated into Turkish by Kökdemir(2003) while forming the items and from the scale of “Logical-Mathematical Thinking” developed by Korkmaz and Yeşil (2010); and they have been added to the item pool. In the selection of the items, firstly, two experts of educational technology have made separate selections and after that, the selected items have been compared and agreement has been reached.

While forming the items in the sub-heading of Communication skills, the questions in the item tool formed by 2 instructors and 4 researchers being expert in the field of instructional technologies have been benefited. At the second stage for the algorithmic thinking, interviews have been made with 13 students who are continuing their education in the senior year of the department of computer and instructional technologies in the faculty of education, these interviews have been examined by 2 experts and 4 researchers and the ideas attained from the interviews have been converted into items of scale. Finally, all the items have been examined by the researchers and decision has been reached as to the convenient items. In the item pool of the scale of Computational Thinking attained at the end of the conducted studies; there are 8 items for the communication skills, 20 items for the algorithmic thinking, 12 items for Critical Thinking, 8 items for Cooperative Learning, 13 items for Creativity and 13 items for problem solving skills. The item pool consists of 74 items in total. After that, the help of an expert of Turkish Language has been taken and the expressions hard to understand in the items and the misstatements have been

controlled and necessary corrections have been made.

Five-point options have been placed as opposed to the formed items for the purpose of determining the levels of the students expressed in the items. These options have been arranged and scored as “(1) never”, “(2) rarely”, (3) sometimes”, “(4) generally” and “(5) always”. The formed draft scale has been examined by 13 students whose comments have been taken beforehand, it has been questioned whether the students have had hardship in understanding the items and how they perceive each item, the items not understood or determined to be understood differently have been examined again and the draft scale has been finalized.

2. 3. Data analysis

Within the frame of the statistical analyses on the data collected with the scale, firstly the KMO and Bartlett analyses have been conducted for the purpose of determining the construct validity of the scale and it has been detected whether factor analysis could be conducted or not. The fact that the KMO value is above 0,90 is interpreted as the fact that the data set is in the excellent level for conducting factor analysis (Russell, 2002). Also; According to the Bartlett values known as the unit matrix of the correlation it tests, it is understood that the zero hypothesis is rejected in 0,05 meaningfulness level (Büyüköztürk, 2002; Eroğlu, 2008).

With regard to the attained values, exploratory and confirmatory factor analyses have been conducted on the data; the status of the scale in distribution to factors has been examined via basic components analysis and the factor loads have been examined with the use of Varimax steep rotation technique. Factor analysis is used for the purpose of revealing whether the items in a scale are distributed into less number of factors or not (Balçı, 2009). Basic components analysis is a technique frequently used

as a factorizing technique (Büyüköztürk, 2002). Within this frame; as a result of the Basic Components Analysis used in the factor analysis, it is necessary that the items whose factor loads are below 0,40 and the items in which there is not at least 0,100 difference between their loads in two factors, in other words, the items whose load is distributed into two factors should be dismissed (Büyüköztürk, 2002). However, the fact that the factor loads of the items taking place in the scale are higher than 0,30 and the fact that at least 40% of the general variance is explained are seen as sufficient in terms of behavior sciences (Büyüköztürk, 2002; Eroğlu, 2008; Kline, 1994; Scherer et al., 1988). However; the fact that the factor loads are 0,50 and above is accepted as very good (Büyüköztürk, 2002). The basic criterion in the assessment of the results of the factor analysis is the factor loads (Balcı, 2009; Gorsuch, 1983; Eroğlu, 2008)). The fact that the factor loads are high is seen as an indicator that the variable may take place below the mentioned factor (Büyüköztürk, 2002). In addition, it is expressed that the calculation of the common factor variance is significant especially in terms of multi-factor patterns and is defined as the common variance caused by the factors on each variable as a result of the factor analysis (Çokluk et.al., 2010). In the event that the common factor variance is below 0,20, there are comments as to the fact that this item should be excluded from the scale (Çokluk et.al., 2010).

The scale form attained with the exploratory factor analysis has been applied to a new study group except for the one to which the first application has been made; and the confirmatory factor analysis has been conducted on the attained values. The confirmatory factor analysis is based on the principle of taking the formulas (items and factors) between the observable and non-observable variables as a hypothesis and testing them (Pohlmann, 2004). In other words, confirmatory factor analysis is a structural equation model that is concerned with the measurement models of the

relations between latent variables and observed measurements. Each factor is explained in terms of the relations between them and the observed variables (items) (Yılmaz and Çelik, 2009; Raykov and Marcoulides, 2006). Maximum likelihood technique has been used in the confirmatory factor analysis. Generally in the structural equation model, it is suggested to report more than one conformity value (Thompson, 2000). For this reason, in this study, five conformity values have been reported. Within this frame, the fact that the values observed in the scale model attained as a result of the confirmatory factor analysis is between the range of $\chi^2/d < 3$; $0 < RMSEA < 0.05$; $0 \leq S-RMR \leq 0.05$; $0.97 \leq NNFI \leq 1$; $0.97 \leq CFI \leq 1$; $0.95 \leq GFI \leq 1$; $0.95 \leq AGFI \leq 1$ and $0.95 \leq IFI \leq 1$ indicates the excellent conformity, the fact that they are between the range of $\chi^2/d < 5$; $0.06 \leq RMSEA < 0.08$; $0.06 \leq S-RMR \leq 0.08$; $0.90 \leq NNFI \leq 0.96$; $0.90 \leq CFI \leq 0.96$; $0.90 \leq GFI \leq 0.96$; $0.90 \leq AGFI \leq 0.96$ and $0.90 \leq IFI \leq 0.96$ indicates the acceptable conformity (Kline, 2005; Şimsek, 2007).

The validity property of the scale has been determined by testing the item distinctiveness powers of the items remaining in the scale as a result of the factor analysis with independent sample t test; and the item-total correlations with Pearson's r test. Finding a correlation between the points attained from each item and the point attained from the factor to which the item belongs to is used as a criterion in terms of understanding the level of servicing the general purpose of the factor (Balçı, 2009). Another value that is observable in terms of testing the level of an item in servicing the general purpose is the corrected correlations. The fact that the corrected correlation coefficients are higher than 0,20 means that an item could serve the purpose of the related factor in a meaningful level (Tavşancıl, 2010). These coefficients are the validity coefficients of each item and they express the consistency of the scale as a whole, in other words, the level of the scale in servicing the general

purpose (Parasuraman, Zeithaml&Berry, 1988: imp. Yüksel, 2009; Carminesi&Zeller, 1982). The property of distinctiveness is accepted as one of the significant proofs used in the determination of the validity of a scale (Büyüköztürk, 2008). Another way to test the distinctiveness of a scale is to observe the differentiation between the lower 27% and upper 27% groups after sequencing the raw points attained from an item in a gradual way.

Internal consistency and constancy tests have been conducted to determine the reliability of the scale. Cronbach alpha reliability coefficient, the correlation value between the two equal-half, Sperman-Brown formula and Guttman's split-half reliability formula have been used in the determination of the internal consistency level. The fact that the reliability coefficient is 0,70 and above is accepted as an indicator of the reliability of a scale (Büyüköztürk, 2002; Gorsuch, 1983). The constancy level of the scale has been calculated by determining the correlation between two application results conducted with 5-week intervals. As it is known, a reliable measurement tools should be able to conduct consistent measurements (Balci, 2009). In addition; reliability is related to the properties of constancy, consistency and preciseness. For this reason, these values determined as constancy coefficient are assessed as a proof of whether the reliability of the scale is high or not (Hovardaoğlu, 2000). The reliability coefficient expressing the consistency degree rises as it gets close to 1,00 and decreases as it gets close to 0,00 (Gorsuch, 1983). As it is known; generally for the correlation coefficients, the level of 0,00 – 0,30 expresses the existence of a low correlation, the level of 0,30 – 0,70 expresses the existence of a medium correlation and the level of 0,70 – 1,00 expresses the existence of a high correlation (Büyüköztürk, 2002).

3. Results

3.1. Findings Regarding the Validity of the Scale

Within the frame of the validity of Computational Thinking Scale (CTS); the construct validity, item-total correlations, corrected correlations and item distinctivenesses have been examined and the findings have been presented below:

3.1.1. Construct Validity

Findings Regarding the Exploratory Factor Analysis: Firstly; the tests of Kaiser-Meyer-Okin (KMO) and Bartlett have been conducted on the data for the purpose of testing the construct validity of CTS and the results have been determined as KMO= 0,914; Bartlett test value $\chi^2= 15886,208$; $sd=2701$ ($p=0,000$). Within the frame of these values, it has been understood that factor analysis could be conducted on the scale consisting of 74 items

At the first stage, basic components analysis has been conducted to determine whether the scale is one-dimensional or not. After that, Varimax steep rotation technique has been used according to the basic components. Within this frame; after 21 items whose item load is below 0,40 at the end of the analyses repeated with multiple stages and 24 items whose load is distributed to different factors, namely a total of 45 items have been excluded from the scale, factor analysis has been conducted again on the remaining items. As explained before; computational thinking skill could be explained with the basic skills such as problem solving, critical thinking, algorithmic thinking, communication and cooperative learning. For this reason, while preparing the item pool, it has been expressed that benefit has been taken from some items taking place in “How Creative Are You?”, “Problem Solving Scale”, “Scale of Cooperative Learning Attitude”, “Scale of California Critical Thinking” and

“Logical-Mathematical Mind Scale”. However, because these skills are so connected to each other, lots of similar items may take place in the mentioned scales. As a result of the conducted analyses, these similar items have been distributed to more than one factor naturally. For this reason, such amount of items (45 items) has been excluded from the item pool obligatorily. For the purpose of sustaining the content validity possible to be distorted due to the excluded items; the attained item pool has been examined again by two educational technologists and two experts of guidance and psychological counseling. Other analyses could be proceeded after the field experts have specified that the remaining items are sufficient in terms of measuring the related skills.

It has been seen that a total of 29 items remaining in the scale as a result of these processes have been categorized under five factors. With its final condition; it has been determined that the KMO value of the scale is 0,880 and the Bartlett values are $\chi^2=7727,897$; $sd=406$; $p<0,001$. It has been seen that the factor loads of the 29 items remaining in the scale are between 0,475 and 0,785 without exposing to any rotation; on the contrary, these loads are between ,494 and ,842 when they are exposed to rotation after the varimax steep rotation technique. On the other hand; it has been determined that the items and factors taken to the scope of the scale explain 56,12% of the total variance. In the next step, the contents of the items in the factors have been examined and the factors have been named. Because the skill levels have been taken into consideration to define the computational thinking skill while forming the item pool, this situation has been taken into account also while naming the factors occurring. The occurring factors coincide with the sub-skills determined while forming the item pool at the beginning to a large extent. Within this frame; 8 items have been collected under the factor called as “Creativity”, 6 under the factor called

as “Algorithmic Thinking”, 4 under the factor called as “Critical Thinking” and 6 under the final factor called as “Problem Solving”.

This situation is also seen in the slope accumulation graphic (Graphic 1) drawn according to the eigenvalues. In Graphic 1, it means that there is high-accelerated decrease in the first five factors; these five factors have a significant contribution due to this; on the contrary, the decrease in the other factors has become horizontal, in other words, their contributions to the variances are close to each other (Büyüköztürk, 2002; Eroğlu, 2008).

(Insert Figure 1)

As a result of these conducted processes, the findings regarding the item loads of the total 29 items remaining in the scale according to the factors and the amounts of the factors in explaining the eigenvalues and variance are presented in Table 2.

(Insert Table 2)

As it could be seen in Table 2; the “Creativity” factor of the scale includes 8 items and the factor loads vary between 0,548 and 0,708. The eigenvalue of this factor within the general scale is 7,19; and its amount of contribution to the general variance is 13,5%. “Algorithmic Thinking” factor includes 6 items. The factor loads of the items are between 0,666 and 0,827. The eigenvalue of the factor within the general scale is 3,19; and its amount of contribution to the general variance is 13,1%.

“Cooperativeness” factor includes 4 items. The factor loads of the items are between 0,685 and 0,842. The eigenvalue of the factor within the general scale is 2,54; and its amount of contribution to the general variance is 10,7%. “Critical Thinking” factor includes 5 items. The factor loads of the items are between 0,533 and 0,764. The eigenvalue of the factor within the general scale is 1,80; and its amount of

contribution to the general variance is 10,1%. “Problem Solving” factor includes 6 items. The factor loads of the items are between 0,494 and 0,720. The eigenvalue of the factor within the general scale is 1,34; and its amount of contribution to the general variance is 8,7%. In addition, because all of the items collected under this factor are reverse, they should be coded reversely while coding.

Findings Regarding the Confirmatory Factor Analysis: Confirmatory factor analysis has been conducted on the data collected from 580 students except for the sample in which the data used for the exploratory factor analysis has been collected regarding the confirmation of the factor structures of the scale detected to be consisting of 5 factors as a result of the exploratory factor analysis.

The estimate values produced for each item as a result of the confirmatory factor analysis conducted with the use of the maximum likelihood technique without making any limitation are presented in Table 3.

(Insert Table 3)

As it could be seen in Table 3, it is seen that 4 of the estimate values are far from 0,70. However; these four items have not been excluded from the scale with the fear that it may negatively affect the content validity. Within this frame; it has been observed that the estimate values of the items are between 0,470 and 0,861.

When the values of the goodness of fit are examined, they have been found as $\chi^2_{(sd=362, N=580)} = 1169,932$, $p < .001$, $CMIN/DF = 3,232$, $RMSEA = 0,062$, $S-RMR = 0,044$, $GFI = 0,91$, $AGFI = 0,90$, $CFI = 0,95$ and $IFI = 0,97$. According to these values, it could be said that the observed fit values show an acceptable goodness (Kline, 2005; Şimsek, 2007). In other words, this attained model reveals that the factors are confirmed by the data. The factorial model of the scale and its values regarding the

factor-item relation are given in Figure 2.

(Insert Figure 2)

3.1.2. Item Factor Total and Corrected Correlations

In this section; the correlations between the points attained from each item in the factors and the points attained from the factors have been calculated according to the item total correlation and corrected item correlation method and the level of each item in servicing the general purpose has been tested. The item-factor correlation values attained for each item are given in Table 4 and the corrected correlation values are given in Table 5.

(Insert Table 4)

As it could be seen in Table 4; the item test correlation coefficients vary between 0,671 and 0,732 for the first factor, between 0,717 and 0,833 for the second factor, between ,788 and ,889 for the third factor, between ,681 and ,809 for the fourth factor and between ,632 and ,677 for the final factor. Each item is in a meaningful and positive relation with the factor in general ($p < 0,000$). According to this, it could be said that each item serves the general purpose of both the factor it is in and also the scale.

(Insert Table 5)

As it could be seen in Table 5, the corrected correlation coefficients with the factor of each item they belong to in the scale vary between ,506 and ,610 for the first factor, between ,599 and ,748 for the second factor, between ,643 and 783 for the third factor, between ,467 and ,663 for the fourth factor and between ,415 and ,496 for the final factor. It could be said that these results support the above results; and according

to this, each item serves the general purpose of both the factor it is in and also the scale.

3.2.3. Item Distinctiveness

The distinctiveness power of the items taking place in the scale has been calculated. For this purpose; firstly, the raw points attained from each item have been gradually sequenced; after that, the lower and upper groups of 196 people each forming the lower 27% and upper 27% groups have been determined. Independent groups t-test values have been calculated on the total points taking place in the groups. The t values regarding the distinctiveness powers and findings regarding the meaningfulness levels are presented in Table 6.

(Insert Table 6)

In Table 6; it is seen that the independent sample t test values regarding the 29 items in the scale and the total point vary between -3,197 and 16,287. T value for the general of the scale has been determined as -37,105. The level of each determined difference is meaningful ($p < 0,001$). According to this; it could be said that the distinctiveness of both the whole and each item of the scale is high. However; it is also seen that the distinctiveness level of the Problem solving factor is lower when compared to other factors.

3.2. Findings Regarding the Reliability of the Scale

Internal consistency and constancy analyses have been conducted on the data for the purpose of calculating the reliability of the scale. The conducted processes and findings are presented below:

3.2.1. Internal Consistency Level

The reliability analysis of the scale according to the factors and as a whole has been calculated with the use of the Cronbach Alpha reliability coefficient, the correlation value between two equal-half, Sperman-Brown formula and Guttmansplit-half reliability formula. The values of the reliability analysis regarding the general of the scale and regarding each factor are summarized in Table 7:

(Insert Table 7)

As it could be seen in Table 7; the two Split Half correlations of the scale consisting of a total of 29 items and the five factors has been determined as ,344; Sperman Brown reliability coefficient as 0,512; GuttmanSplit-Half value as ,498; Cronbach Alpha reliability coefficient as ,822. On the other hand; it is seen that the split half correlations regarding the factors vary between ,406 and ,713; Sperman Brown values between ,578 and ,832; GuttmanSplit-Half values between ,578 and ,832 and Cronbach's Alpha values between 0,727 and 0,869. According to this, it could be said that both each factor and the scale in general could conduct consistent measurements.

3.2.2. Constancy Level

The constancy level of the scale has been detected with the use of test re-test method. The final form of the scale consisting of 29 items has been applied to 51 students on which application has been carried out after three weeks again. The relation between the points attained at the end of both applications has been taken into consideration both in terms of each item and the whole of the scale. In this way; the property of both each item taking place in the scale and the whole of the scale in conducting consistent measurements has been tested and the findings have been summarized in Table 8.

(Insert Table 8)

In Table 8; it is seen that the correlation coefficients of each item forming the scale attained with the method of test re-test vary between 0,317 and 0,671 and each relation is meaningful and positive. The correlation coefficients of the factors forming the scale attained with test re-test method vary between ,371 and ,613. The correlation regarding the total point is ,512 and it is seen that each relation is meaningful and positive. According to this, it could be said that the scale could make consistent measurements.

4. Discussion

In this study, a scale has been developed for the purpose of determining the computational thinking skill levels of the students. CTS is a five-point likert type scale and consists of 29 items that could be collected under five factors. Each one of the items taking place in the factors has been scaled as never (1), rarely (2), sometimes (3), generally (4), always (5). The validity of the scale has been examined with two different methods. These are the methods of (1) factor analysis and (2) testing of validity via the distinctiveness properties.

When the factor loads of the items in the factors, eigenvalues of the factors and the explained variance rates are taken into consideration, it could be said that the scale has construct validity. Confirmatory factor analysis has been conducted to verify the factor structures of the scale detected to be consisting of 5 factors as a result of the exploratory factor analysis. As a result of the conducted confirmatory factor analysis; the observed values of the scale model reveal that the data show conformity, in other words, this attained model has been verified by the data.

Total item correlations and corrected correlations have been calculated on the data in order to identify at what level each one of the items in the scale measure the factor it belongs to and the properties to be measured. According to the attained values, it has been identified that each item and each factor in the scale serve the purpose of measuring the property to be measured and the whole of the scale at meaningful level. Additionally, the item distinctiveness levels have been investigated by examining t values related to the difference between upper 27% and lower 27% groups and it has been determined that both the whole of the scale and each item have high distinctiveness; in other words, each item is distinctive at the required level. The internal consistency coefficients of the scale have been calculated by using two split half correlations, Cronbach Alpha, Spearman-Brown formula and Guttman's split-half reliability formula. Within the scope of these calculated values, it has been determined that the scale can make reliable measurements. The constancy level of the scale according to time has been investigated by using test re-test method. Test re-test method has been calculated within the scope of sub factors of the scale and for each item and it has been identified that each factor and each item can make decisive measurements as constancy according to time.

Although it has been expected to emerge a structure having six factors according to ISTE (2015) as a result of the analysis related to construct validity, a structure with five factors has emerged. When the items coming under factors have been examined, it has been seen that communication skills and a great part of the related items have come under the factors of critical thinking, problem solving and cooperative learning. It has been decided that the situation is acceptable thinking that the communication skills have a fundamental qualification in the occurrence of the skills mentioned above and the structure with five factors has been maintained. Thus, communication

can be simply defined as people sharing emotions, thoughts and information (Karatekin, Sönmez, & Kuş, 2012). In other words, communication is a process occurring by people's sharing their emotions, thoughts and information with each other in order to understand each other (Üstün, 2005). In this context, it will not be wrong to say that communication is the basis of cooperative learning, critical thinking and problem solving skills. The remaining five factors can be explained shortly as:

Creativity: Craft (2003) has explained the creativeness as an ability that is not related only to art and that continues lifelong and defined it as self expression, the capacity to use intelligence and imagination. According to Aksoy (2004), creativity is to introduce new relations and form new combinations from one or more concepts in the mind for the purpose of looking at the events from different aspects. Everything that is created is the new combinations of the ideas, products, colors and the words. Creativeness is ended up with scientific discoveries, new products, art and literature.

Algorithmic Thinking: Algorithmic thinking is the ability to think, understand the algorithms, apply, evaluate and produce (Brown, 2015). *Critical Thinking:* According to Halpern (1996), critical thinking has been defined as “using cognitive skills or strategies increasing the possibility of the intended behaviors”. *Problem Solving:* The obstacle on the way that someone finds to reach the intended purpose is called Problem. If someone meets with some obstacles while endeavoring to reach a certain purpose or intellection, it means there is a problem for that person (Aksoy, 2004).

Cooperativity: Cooperative learning is a learning method in which learning of both individual and group members of the small groups are tried to be maximized (Veenman, Benthum, Bootsma, Dieren, & Kemp, 2002).

5. Conclusion

It could be said that statistically CTS is a valid and reliable scale that could be used in the identification of the computational thinking levels of students. Since there has not been encountered a valid and reliable measurement tool aiming at measuring the computational thinking levels as a whole in the literature, it could be thought that this measurement tool could make important contributions to literature. However, the validity and the reliability of the scale should be done to use it for different groups and purposes. It should be considered that each scale can be valid and reliable for its own group. Besides, the validity and reliability studies of the measurement tool have been conducted by the participation of 1306 participants consisting of the students studying at different associate, undergraduate and post graduate degrees and graduated from undergraduate degrees and having pedagogical formation. That the participants are from different education levels and age groups has given an opportunity to use the scale in different groups. However, it is suggested that the validity and reliability analysis are done again when it is wanted to be used in the groups in the scope of the study. On the other hand, five factor point obtained from the scale could be used separately; it could also be used as total point.

However; this study is limited to the associate students and the students studying in higher levels. Adaptation study should be conducted in the event that this study is desired to be applied to the high school students or the students in lower grades. In addition; computational thinking is limited to the sub-skills expressed in the definition made by ISTE (2015) in this scale and to the basic items taking place in the scales developed separately for these skills

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Figure caption page

Figure 1. Screen plot graphic (eigenvalues according to the factors).

Figure 2. Confirmatory factor analysis diagram of the scale

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Tables

Table 1. The distribution of the study group according to the University, Class and gender

Department	I. Implementation			II. Implementation		
	Female	Male	Total	Female	Male	Total
Pri. Math Ed.	30	10	40			
Science Ed.	51	21	72			
CEIT	34	52	86			
Pri. Clas. Ed	2	3	5			
Türkish Ed.	32	13	45			
Psch. Cons and Guid.	75	27	102			
Soc. Sci. Ed..	43	46	89			
Comp. Prog.	32	60	92			
Mech .Eng.	8	45	53			
Elec-Elect Eng.	19	81	100			
Math				48	50	98
Biology				42	11	53
Geograph				3	7	10
Liteature				53	34	87
Philosoph				27	3	30
Phisics				11	16	27
Theology				71	45	116
Chemistry				13	10	23
Healty Sci.				79	13	92
History				26	18	44
Total	358	326	684	373	207	580

*. 42 students have not specified their department or gender in the first application.

Table 2. Factor analysis results of the scale as per factors

Items	Com. Fact.	F1	F2	F3	F4	F5
159 I like the people who are sure of most of their decisions	,592	,708				
158 I like the people who are realistic and neutral	,628	,703				
169 I believe that I can solve most of the problems I face if I have sufficient amount of time and if I show effort.	,643	,686				
170 I have a belief that I can solve the problems possible to occur when I encounter with a new situation.	,659	,658				
167 I trust that I can apply the plan while making it to solve a problem of mine.	,533	,629				
157 Dreaming causes my most important projects to come to light.	,586	,609				
156 I trust my intuitions and feelings of "trueness" and "wrongness" when I approach the solution of a problem	,593	,579				
166 When I encounter with a problem, I stop before proceeding to another subject and think over that problem.	,476	,548				

Creativity

Algorithmic Thinking	I26	I can immediately establish the equity that will give the solution of a problem	,731	,827			
	I25	I think that I have a special interest in the mathematical processes	,719	,824			
	I28	I think that I learn better the instructions made with the help of mathematical symbols and concepts	,688	,808			
	I27	I believe that I can easily catch the relation between the figures	,491	,719			
	I22	I can mathematically express the solution ways of the problems I face in the daily life.	,578	,673			
	I19	I can digitize a mathematical problem expressed verbally.	,625	,666			
	Cooperativity	I42	I like experiencing cooperative learning together with my group friends.	,785	,842		
I46		In the cooperative learning, I think that I attain/will attain more successful results because I am working in a group.	,693	,818			
I41		I like solving problems related to group project together with my friends in cooperative learning.	,728	,817			
I45		More ideas occur in cooperative learning.	,632	,685			
Critical Thinking	I38	I am good at preparing regular plans regarding the solution of the complex problems.	,723	,764			
	I37	It is fun to try to solve the complex problems.	,747	,726			
	I35	I am willing to learn challenging things.	,633	,652			
	I39	I am proud of being able to think with a great precision.	,648	,597			
	I72	I make use of a systematic method while comparing the options at my hand and while reaching a decision.	,599	,533			
Problem Solving	I21	I have problems in the demonstration of the solution of a problem in my mind.	,610	,720			
	I20	I have problems in the issue of where and how I should use the variables such as X and Y in the solution of a problem.	,660	,675			
	I18	I cannot apply the solution ways I plan respectively and gradually.	,638	,666			
	I68	I cannot produce so many options while thinking of the possible solution ways regarding a problem.	,582	,638			
	I48	I cannot develop my own ideas in the environment of cooperative learning.	,674	,532			
	I47	It tires me to try to learn something together with my group friends in cooperative learning.	,604	,494			
Eigenvalue			7,19	3,39	2,54	1,80	1,34
Explainedvariance			13,5	13,1	10,7	10,1	8,7

Table 3.Standardized Regression Weights

I. No	Estimate	I. No	Estimate
m59 <---	,739	m38 <---	,749
m58 <---	,758	m37 <---	,744
m69 <---	,779	m35 <---	,679

m70 <--- ,801	m39 <--- ,667
m67 <--- ,785	m72 <--- ,536
m57 <--- ,629	m21 <--- ,633
m56 <--- ,650	m20 <--- ,545
m66 <--- ,745	m18 <--- ,470
m26 <--- ,858	m68 <--- ,544
m25 <--- ,825	m48 <--- ,754
m28 <--- ,794	m47 <--- ,719
m27 <--- ,861	m42 <--- ,850
m22 <--- ,676	m46 <--- ,764
m9 <--- ,690	m41 <--- ,874

Table 4.Item-factor scores correlation analysis

F1 Creativity		F2 AlgorithmicThinking		F3 Cooperativity		F4 Critical Thinking		F5 Problem Solving	
I	r	I	r	I	r	I	r	I	R
I59	,678**	I26	,833**	I42	,889**	I38	,809**	I21	,677**
I58	,674**	I25	,831**	I46	,837**	I37	,780**	I20	,639**
I69	,732**	I28	,832**	I41	,861**	I35	,687**	I18	,633**
I70	,722**	I27	,759**	I45	,788**	I39	,707**	I68	,632**
I67	,722**	I22	,736**			I72	,681**	I48	,684**
I57	,680**	I9	,717**					I47	,640**
I56	,643**								
I66	,671**								

N=726; **=p<, 001

Table 5.Item-factor scores corrected correlation analysis

F1 Creativity		F2 AlgorithmicThinking		F3 Cooperativity		F4 Critical Thinking		F5 Problem Solving	
I	r	I	r	I	r	I	r	I	R
I59	,546	I26	,748	I42	,783	I38	,663	I21	,496
I58	,542	I25	,733	I46	,689	I37	,629	I20	,429
I69	,610	I28	,745	I41	,731	I35	,481	I18	,415
I70	,610	I27	,604	I45	,643	I39	,532	I68	,441
I67	,608	I22	,617			I72	,467	I48	,484
I57	,528	I9	,599					I47	,443
I56	,506								
I66	,537								

N=726

Table 6.Item Discrimination Powers

F1 Creativity		F2 AlgorithmicThinking		F3 Cooperativity		F4 Critical Thinking		F5 Problem Solving	
I	t	I	t	I	t	I	t	I	t
I59	-8,959	I26	-17,483	I42	-10,868	I38	-17,112	I21	-7,123
I58	-7,526	I25	-15,750	I46	-6,839	I37	-16,421	I20	5,486
I69	-11,515	I28	-16,287	I41	-10,582	I35	-11,646	I18	-4,610
I70	-13,939	I27	-10,677	I45	-7,757	I39	-13,032	I68	-3,197
I67	-13,461	I22	-14,293			I72	-14,597	I48	-4,309
I57	-9,661	I9	-12,106					I47	-3,234
I56	-15,075								
I66	-11,526							FT	-37,105
F1	-18,449	F2	-21,253	F3	-10,826	F4	-22,520	F5	-8,241

*df: 390; $p < ,001$ **Table 7.** Reliability analysis results considering the whole of the scale and its factors.

Factor	Number of items	Two congruent halves correlation	Sperman Brown	Guttman Split-Half	Cronbach's Alpha
Creativity	8	,713	,832	,832	,843
Algorithmic Thinking	6	,756	,861	,860	,869
Cooperativity	4	,835	,910	,908	,865
Critical Thinking?	5	,562	,719	,687	,784
Problem Solving	6	,406	,578	,578	,727
Total	29	,344	,512	,498	,822

Table 8. Test-retest results of the items of the scale.

F1 Creativity		F2 Algorithmic Thinking		F3 Cooperativity		F4 Critical Thinking		F5 Problem Solving	
I	r.	I	r	I	r	I	r	I	r
I59	,612**	I26	,578**	I42	,591**	I38	,419*	I21	,412*
I58	,578**	I25	,591**	I46	,609**	I37	,439**	I20	,398*
I69	,621**	I28	,612**	I41	,601**	I35	,534**	I18	,432**
I70	,453**	I27	,607**	I45	,634**	I39	,497**	I68	,476**
I67	,498**	I22	,609**			I72	,501**	I48	,373*
I57	,671**	I9						I47	,317*
I56	,663**								
I66	,621**							FT	,512**
F1	,613**	F2	,598*	F3	,601*	F4	,503**	F5	,371*

N: 51; *= $p < 0,05$; **= $p < 0,001$

