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CHANGE OF TEACHERS' METAPHORS TOWARDS STEM AND 21ST CENTURY SKILLS WITH STEM COURSE

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ABSTRACT

The aim of this study was to reveal the changes in metaphorical perceptions of teachers received STEM course towards STEM and 21st century skills. In this study adopted an instrumental case study to find out the change in teachers' metaphoric perceptions of STEM and 21st century skills. The changes in teachers' perception of STEM and 21st century skills were tried to be reflected by using metaphors. The data of 24 teachers were included in the study group in order to obtain qualified data. Using the metaphor form developed by the researchers, data on STEM and 21st century skills were collected from 24 teachers. The data was collected from the participants and analyzed separately by two researchers by using content analysis method. Afterwords, researchers came together with the third researcher and the similarities and differences of the analyzes were determined. Considering these similarities and differences, the reliability coefficient of the study was calculated and found .75. The metaphors and conceptual categories obtained as a result of the research show that teachers created limited metaphors for their knowledge of STEM and 21st century skills before STEM course, while they created more comprehensive metaphors for STEM and 21st century skills as a result of their awareness and knowledge after STEM course.

Keywords: 21st Century Skills, Stem, Metaphor, Teachers, Stem Course

INTRODUCTION

Nowadays, the impact of technology and science on education gradually increases. Science and technology bring about various innovations in the field of education as well as in every field. This situation causes the understanding of education to differ.

Educational technologies and resources support more student-centered teaching implementations, unlike traditional education existing for centuries in the educational process (Bonk, 2009). In this way, learning can be defined as constructing and making sense of knowledge with mental skills, rather than as "a change in behavior" (Fosnot, 2005). With this definition of learning, constructivism in education has come to the fore. Constructivism advocating that learning takes place as a result of students' interaction with their environment and social environment effectively; is defined as a philosophical view that defines the process of creating post-positivist, interpretive and nonlinear information (Bada &

Olusegun, 2015; Fosnot & Perry, 2005; Gredler, 2009; Schunk, 2012). Considering constructivism, there is a need for constant change in education standards and educational objectives. Accordingly, it is necessary to change the frameworks of education programs, teaching methods and evaluation strategies (Saavedra & Opfer, 2012).

Due to the new views adopted in learning-teaching environment and the widespread of educational technologies, it is inevitable to make various changes in education programs and learning-teaching processes. With the changes of curricula, students and teachers encounter innovations in many fields. Today, 21st century skills and their adaptation to education systems are taken into consideration in the change of curricula. The 21st century skills framework was developed by the National Research Council (NRC) for reasons such as educating students and changing the standards during the evaluation of education in the context of technology development and differentiating top-level skills (Jang, 2016). The essence of 21st century skills is to focus on what students can do with the information they have structured rather than their knowledge (Silva, 2009). In addition, these skills enable individuals to create a well-prepared workforce for the future, as well as life skills that help all individuals succeed throughout their lives (Beers, 2011). 21st century skills are grouped under three sub-titles within the scope of the foreseeable skills (Johnson, 2009; Partnership for 21st Century Learning, 2009): "Learning and Innovation Skills", "Information, Media and Technology Skills" and "Life and Career Skills". Learning and Innovation Skills are examined under the subtitles of creativity and innovation, critical thinking and problem solving, communication and collaboration; Information, Media and Technology Skills are examined under the subtitles of information literacy, media literacy and ICT (information, communications, and technology) literacy; Life and Career Skills are examined under the subtitles of flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility (Chu, Reynolds, Tavares, Notari & Lee, 2017). How to incorporate 21st century skills into the classroom and how to integrate technology into the learning environment may drastically change the learning and teaching process. For this reason, starting from these skills and different educational approaches, teaching and learning standards have become a necessity to bring out new educational situations that try to meet the needs of 21st century skills (Gewertz, 2008).

Students in the 21st century are expected to demonstrate previously unknown insights and skills. These skills prepare students to actively participate in future initiatives (Roberts, 2012). However, it is deemed important to find new ways as to how effective the standards-based educational environments adopted to gain these skills are debatable. STEM (Science, Technology, Engineering and Mathematics) education comes to the forefront as an education concept directed by the technology, changing global economy and labor needs, which has become an international debate and developed in recent years (Kennedy & Odell, 2014). STEM was first used as an abbreviation of "Science, Technology, Engineering and Mathematics" by the National Science Foundation in the United States in the 1990s (Sanders, 2015). STEM focuses on the interdisciplinary nature of these areas (Çalışıcı & Sümen, 2018). Although there are definitions covering a large philosophical spectrum that helps design STEM as a simple meta discipline; in essence, it is a way to make each subject meaningful by contextualizing it among others (Ostler, 2012). STEM education, also defined as integrative, refers to technological/engineering design-based learning approaches that deliberately integrate the content and process of science and/or mathematics education with the content and process of technology and/or engineering education. In addition, integrative STEM education can be developed through further integration with different school subjects such as language, social studies, art and etc. (Sanders, 2015).

STEM education and practices become widespread in many countries and take their place in the education systems of countries. In Turkey, some changes have been made in this regard since 2017 education year. New arrangements and initiatives have been started in curriculum and in other areas of education in accordance with STEM education (Çepni, 2018). Considering the STEM Education Report (Ministry of National Education, 2016), which is accepted as one of these initiatives, STEM education in Turkey focuses on literacy skills in the universal sense and emphasizes the need to acquire these skills such as creative thinking, critical thinking, problem solving and collaborative working in the context of 21st century. However, in order to provide STEM education effectively and enable students to learn,

firstly teachers should be qualified in this field (Stohlmann, Moore & Roehrig, 2012) since understanding the various contents in a holistic way and transferring these contents to students is a very difficult and expert work. For this reason, it is necessary to increase the number and quality of STEM teachers in order to help students develop their 21st century skills and innovative capacities (Çorlu, Capraro & Capraro, 2014).

Based on the STEM definitions, it is seen in the literature that the concept of STEM is generally emphasized in relation to the concept of STEM literacy and STEM education. In this context, how STEM education is perceived and defined by teachers is important for being an effective teacher in practice. This can be come to light through metaphors. Metaphor means to explain or characterize a certain situation, event, phenomenon or discourse by symbolizing or characterizing them in various meanings (Ortony, 1993). From this point of view, to explain a concept through metaphor, it is to present the perspectives of individuals regarding that concept in order to make sense of it (Cheney, McMillan & Schwartzman, 1997). For this reason, metaphor studies are frequently used to describe how these concepts are perceived by individuals for learning, teaching, school, curriculum and similar concepts in education in the context of students, teachers or school administrators (Inbar, 1996). However, metaphor studies related to STEM education, which is described as a new concept, have not become widespread yet. In the literature, studies were generally carried out with teachers, students and prospective teachers in the context of STEM education. One of the studies that attempts to reveal how STEM education is perceived by teachers and administrators, it was represented that the participants do not fully understand what STEM education is and cannot define the elements that constitute STEM (Brown, Brown, Reardon & Merrill, 2011). Cannady, Greenwald and Harris (2014) tried to clarify the general framework and educational policies of STEM education which was described using the 'pipeline' metaphor in their study. In another study conducted by El-Deghaidy and Mansour (2015), science teachers accepted that STEM education could help them to develop 21st century skills such as thinking skills, collaboration, problem solving, and research skills that may be useful for choosing a career. However, it was found that teachers were not ready to practice because they cannot fully understand and explain how to integrate STEM components into lessons. Similarly, in another study with teachers, it was emphasized that teachers' STEM perception and understanding of this information were at the core of the effectiveness of their own classroom practices of STEM education and teachers' personal knowledge in this area (Bell, 2016). In a metaphor study conducted by Çalışıcı & Sümen (2018) with 138 teacher candidates, it was determined that STEM education was generally perceived by teacher candidates as a complementary concept. The study conducted by Idin and Dönmez (2018) with 94 secondary school students, it was emphasized that student metaphors were not very descriptive for the components of STEM education and that students did not have sufficient knowledge about mathematics and engineering.

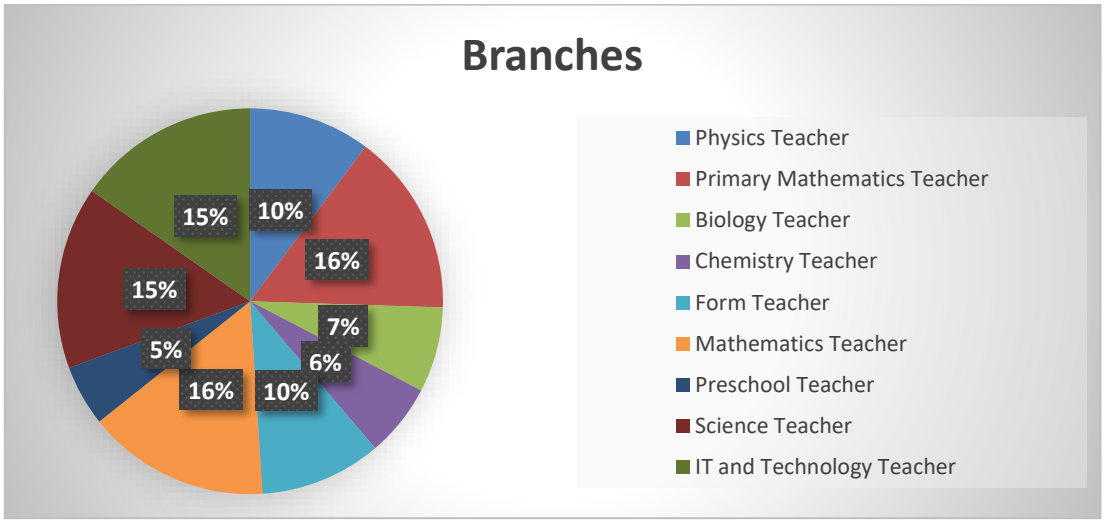
Based on the studies in the literature, it is emphasized that STEM education and STEM components are not fully perceived by students, teachers and also administrators, flaws in perceptions cause problems in practice and this can be overcome by increasing the awareness of teachers. Considering all these, in this study, it is aimed to reveal the changes in metaphorical perceptions of teachers received STEM course towards STEM and 21st century skills

METHODOLOGY

This study adopted the instrumental case study to reveal the change in teachers' metaphoric perceptions of STEM and 21st century skills. According to the instrumental case study, a single event is focused to reveal a specific event or to rearrange a theory. In instrumental case study design studies, the event is secondary and it helps us learn about the change of things (Stake, 2003). In addition, Stake states that the events in the instrumental case study will be more appropriate to be used for the investigation of change or effects. For this reason, the study was carried out using the instrumental case study method, as it acted as a tool for the STEM course in determining how teachers changed their metaphors about STEM and 21st century skills. In addition, in this study, it is aimed to convert experience into recognition and analyze the experience (McMillian & Schumacher, 2010). Metaphors are often used to determine experiences. This pattern includes identifying the subject for metaphor analysis and planning research,

defining and collecting metaphors, and clustering them into metaphorical concepts (Schmitt, 2005). The metaphors used in this pattern allow individuals to explore perceptions from different perspectives that revive their new experiences. Additively, metaphors are used to reveal the change in human perception and actions over time (Saban, 2010). Therefore, in this study, the changes in teachers' perception of STEM and 21st century skills were tried to be revealed by using metaphors.

The participants of the study were 120 teachers. However, the data of 24 teachers were included in the study group in order to carry out the study in two stages and to obtain qualified data. The lack of metaphors or explanations created by 96 teachers outside the study group and the lack of metaphors or explanations before or after the education caused the data not to be used. The distribution of the 24 teachers in the study by branches is as follows: physics teacher (2), primary mathematics teacher (3), biology teacher (3), chemistry teacher (4), form teacher (2), mathematics teacher (3), preschool teacher (1), science teacher (3), IT and technology teacher (3) (Graphic 1).



Graphic 1. Branch Distributions of Teachers

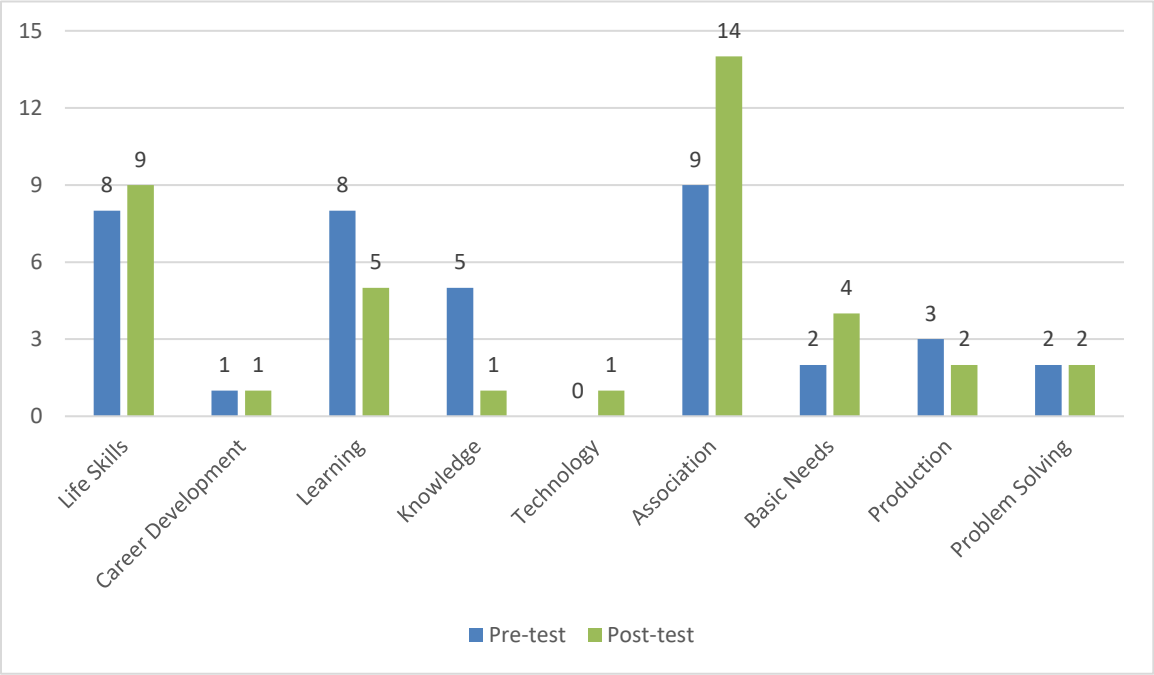
This research was carried out in two stages: before in-service STEM education and after in-service STEM education. In the research process, the data were collected with metaphor form containing "STEM is like..... because....." and "21st century skills are like..... because....." metaphor-explanation sentences in order to determine the change in the metaphoric perceptions of the teachers participating in in-service education. The questions in the interview form given to the teachers were filled out by the teachers and delivered to the researchers in writings.

The data collected from the participants were analyzed with content analysis method. In content analysis method, code, category and theme are created during the analysis of data collected from the participants (McMillan & Schumacher, 2010). For this reason, in order to create common codes, categories and themes, two researchers in the study came together and analyzed and accepted the metaphors of the teachers as codes. Metaphor explanations and metaphors created by the teachers were evaluated together and it was determined which category the metaphor would pertain. In order to determine the changes in teachers' metaphors and explanations after in-service education, both metaphors, explanations and categories formed by the researchers were examined by two researchers and differences and similarities were determined. For the reliability of the research analysis, the data analyzed by the two researchers were checked by the third researcher who conducted the research and the differences were determined. Considering similarities and differences, the reliability coefficient of the study was calculated as .75 by using the reliability coefficient formula developed by Miles and Huberman (1994). According to the coding control, which gives reliability coefficient, the consensus between coders is expected to be between .80 and .90 (Miles & Huberman, 1994). In addition, Miles and Huberman states that reaching coefficients as high as .90 will be beneficial in terms of reliability coefficient and that coefficients above .70 will be sufficient to ensure reliability coefficient (Hruschka et

al., 2004). Depending on these implications, since the reliability coefficient was higher than .70, the data analysis of the study was considered to be reliable.

FINDINGS

In this section, the changes in the metaphors that teachers created for STEM and 21st century skills within the scope of in-service education was explained with graphs and tables. In order to determine the change, the metaphors collected from the teachers in the pre-form and post-form were examined by considering certain categories. It was tried to explain whether there is a change by including the explanations of teachers using the same metaphor in pre-form and post-form and concluding there was no change.



Graphic 2. Change in teachers' metaphoric perceptions of STEM

According to Graphic 2, teachers created metaphors in nine categories for STEM. It is found that the metaphors teachers created were mostly related to the categories of association, life skills and learning. In addition, teachers created metaphors including categories of professional development, knowledge, technology, basic needs, production and problem solving. Comparing the pre-form and post-form, it was found that there was an increase in the number of metaphors created by teachers to the categories of life skills, technology, association and basic needs. There was no change in the number of metaphors for the categories of professional development and problem solving. However, the number of metaphors for the categories of learning, knowledge and production decreased.

Table 1
Pre-form and post-form metaphors of STEM

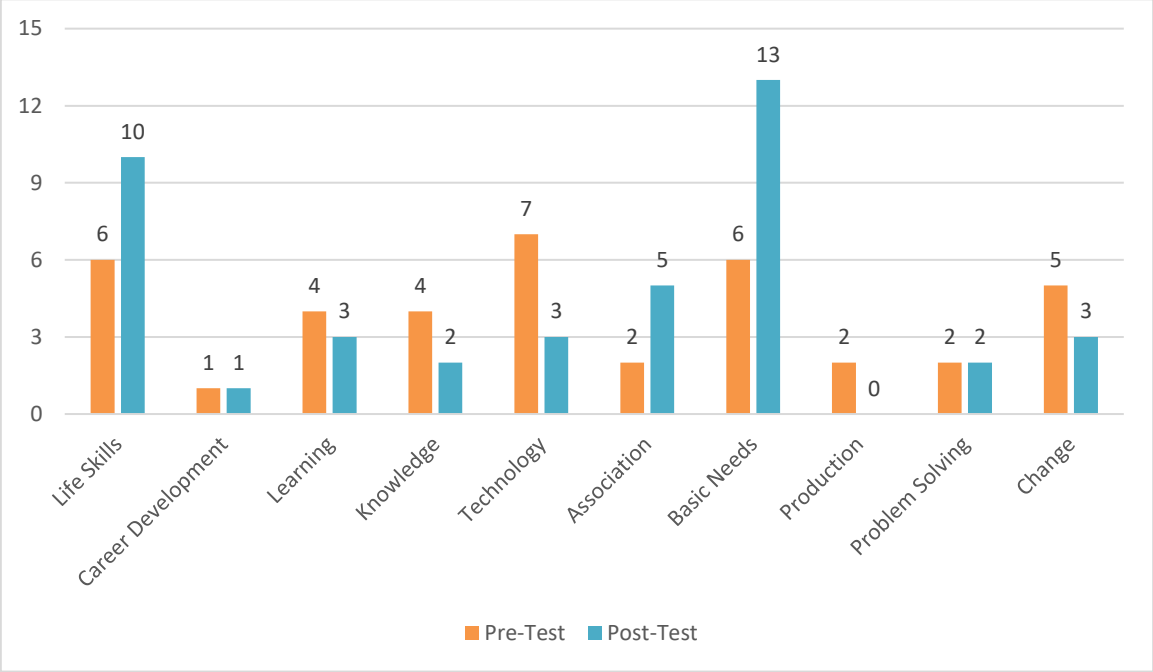
Category	Pre-Form	Post-Form
Life Skills	Engineering, Physical Education, Seed, Teacher, Daylight, Repairman, Roots of the Flower, Mother	Play Dough, Game, To Live, Teacher, Baby, Factory, Mother, Vita, Life
Career Development	Modern Consultant	Compass
Learning	Information Processing and Using Skill, Dream, Catalyzer, Day and	Navigation, Teacher, Factory, Mother, Water

Knowledge	Night, Modern Consultant, School, Roots of the Flower, Mother Engineering, Information Processing and Using Skill, Factory, Catalyzer, Night-Day	Navigation
Technology		Bee
Association	Bridge, Cooking, Equipped Engineer, School, Nutrient, Three in One, The Universe Itself, Key, Education System	Mother, Factory(2), Bee, Painting, Overall Body System, Person from Black Sea, Company, Repair Kit, Multidisciplinary Education, Life, Soup, Whole
Basic Needs	Daylight, Nutrient	Water (2), To Live, Baby
Production	Factory (2), Cooking	Factory (2)
Problem Solving	Repairman, Teacher	Navigation, Life

As shown in Table 1, a total of 22 different metaphors were created for eight categories except the technology category in the pre-form, while 21 different metaphors for nine categories were created in the post-test. Metaphors created by the teachers in pre-test include key, mother, nutrient, information processing and using skill, roots of the flower, equipped engineer, education system, the universe itself, factory, day and night, daylight, dream, catalyzer, bridge, modern consultant, engineering, school, teacher physical education the last lesson on Friday, repairman, seed, three-in-one and cooking. Metaphors created by the teachers in post-test include mother, bee, baby, whole, multidisciplinary education, soup, factory, life, overall human body, person from Black Sea, navigation, game, play dough, teacher, compass, painting, water, company, repair kit, living and life. Teachers created different metaphors in the pre-form and post-form except T7 and T14 who created the same metaphor in the pre-form and post-form. T7 created the "teacher" metaphor for STEM in the pre-form and post-form. T7 made a statement as "...is open to innovation and produces solutions to problems" in the pre-form. It was determined that T7 created a metaphor for the categories of life skills and problem solving. In the post-form, as he explained that "it provides interdisciplinary learning by living and doing", it was considered a metaphor for the categories of life skills, learning and association. It was determined that T14 developed a metaphor for the production category, since T14 explained that "it produces new products" using the "factory" metaphor in the pre-form and post-form for STEM. In the post-form, T14 also used the "factory" metaphor, however, as he stated "with the merger of many parts, new products were produced" it was found that the metaphor belongs to the categories of association and production. As a result of in-service education, even if there were no changes in metaphors created by T7 and T14, there was a difference in metaphor explanations. T15 created the "equipped engineer" metaphor in the pre-form and "person from Black Sea" in the post-form. Although the metaphor created by T15 changed in the pre-form and post-form, the explanation of "requires some understanding of everything" remained the same. Considering the explanation given by the participant, the metaphor was placed in the category of association. In addition, although there were changes in the metaphors created by T2, T12, T13, T20, T23 and T24, there was no change in the categories in which the metaphors were placed (Table 2).

Table 2
Teachers and Their Metaphors without Change in Categories for STEM Metaphors

Code of Teacher	Pre-Form Metaphor	Post-Form Metaphor	Category
T_2	Physical Education	Play Dough	Life Skills
T_{12}	Cooking	Overall Body System	Overarching
T_{13}	Modern Consultant	Compass	Career Development
T_{20}	Three in One	Repair Kit	Overarching
T_{23}	Key	Soup	Overarching
T_{24}	Education System	Whole	Overarching



Graphic 3. Change in teachers' metaphoric perceptions of 21st century skills

According to Graphic 3, teachers created metaphors in 10 categories for 21st century skills. It was identified that the metaphors created by the teachers were mostly related to the categories of basic needs, life skills and technology. In addition, teachers created metaphors including the categories of professional development, learning, knowledge, association, production, problem solving and change. Comparing the pre-form and post-form results, it was found that there was an increase in the number of metaphors created by the teachers to the categories of life skills, association and basic needs in the post-form. There was no change in the number of metaphors for the categories of professional development and problem solving; there was a decrease in the number of metaphors for the categories of learning, knowledge, technology, production and change.

Table 3
Pre-Form and Post-Form Metaphors Of 21st Century Skills

Category	Pre-Form	Post-Form
Life Skills	Improving and Teaching, Investment in the Future, Cutlery, Updating, Innovation, Digital Literacy	Instructions for use, Child, Life Skill, Innovations of the Age, Cheetah, Updating, Innovation, Life Skills, Air-Water, Creativity
Career Development	Inventor	Housewife
Learning	Improving and Teaching, Maths Problem, New Behavior Style, Learning	Child, Water, Cheetah
Knowledge	STEM, Lazy Student, Innovation, Computer	Life Skills, Mixed Herbal Tea
Technology	Robotics (2), Television, Innovation, Technology, Computer, Digital Literacy	Computer, Technology, Mixed Herbal Tea
Association	STEM, Jigsaw Puzzle	Spider Web, Healthy Nourishment, Housewife, Teacher, Mixed Herbal Tea

Basic Needs	Key, Tire, Fast Food, Sun, Cutlery, Updating	Instructions for use, Water (3), Meter, Life Skills, Breast Milk, Healthy Nourishment, Multifunction, Updating, Life, Teacher, Air-Water
Production	STEM, Inventor	
Problem Solving	Key, Maths Problem	Internet, Creativity
Change	Television, Innovation, Technology, New Behavior Style, Versatile Improvement	Computer, Technology, Life Skills

As shown in Table 3, 21 different metaphors were created for 10 categories in the pre-form and 22 different metaphors for 9 categories in the post-form. Metaphors created by the teachers in pre-form include key, computer, cutlery, versatile improvement, digital literacy, fast food, investment in the future, improving and teaching, updating, sun, innovation, tire, maths problem, inventor, robotics, STEM, technology, television, lazy student, jigsaw puzzle and new behavior style. Metaphors created by the teachers in post-form include breast milk, computer, children, innovations of the age, cheetah, multifunction, healthy nourishment, updating, air, water, life skills, internet, mixed herbal tea, instruction for use, ingenious housewife, teacher, spider web, water, technology, meter, creativity, life and life skills. Teachers created different metaphors in the pre-form and post-form except T14 who created the same metaphor in the pre-form and post-form. T14 created the "update" metaphor for 21st century skills in the pre-form and post-form. In the pre-form, T14 explained that "people should have the skills suitable for today's conditions" while in the post-form, he stated that "it includes the skills needed to adapt to today's conditions."

Although the explanations of the metaphors were expressed differently in the pre-form and post-form, there were no semantic differences. Therefore, in the pre-form and post-form, the metaphor was placed in the category for life skills and basic needs. In addition, although there were changes in the metaphors created by T2, T4 and T14, there were no changes in the categories in which the metaphors were placed (Table 4).

Table 4
Teachers and Their Metaphors Without Change in Categories for 21st Century Skills Metaphors

Code of Teacher	Pre-Form Metaphor	Post-Form Metaphor	Category
T_2	Tire	Water	Basic Needs
T_4	Fast food	Meter	Basic Needs
T_{14}	Updating	Updating	Life and Basic Skills

DISCUSSION

As a result of the in-service STEM education of teachers, it is concluded that the metaphors and metaphor explanations that teachers created for STEM and 21st century skills differed significantly in the post-form.

In the pre-form related to STEM, teachers created metaphors for the categories of association, life skills, learning, knowledge, production, problem solving, basic needs and career development in descending order. In the post-form, they created metaphors for the categories of association, life skills, learning, basic needs, production, problem solving, career development, knowledge and technology in descending order. When the metaphors and explanations of the teachers about STEM in the pre-form and post-form are examined, it is concluded that the metaphors created in the post-form can be explained in more categories than the pre-form (Table 1). It shows that teachers considered STEM more narrowly before in-service education but after in-service education, teachers considered STEM as an interdisciplinary approach. STEM requires different skills to be integrated into a process (Chai, 2019; Çorlu, Capraro & Capraro, 2014). When this situation is taken into consideration, it is concluded that teachers associate STEM with different situations at the end of in-service education. For instance, in the

pre-form, for the metaphor of technology, which is accepted as a component of STEM (Chai, 2019), none of the teachers created a metaphor, whereas, the metaphor for technology was created in the post-form. Furthermore, at the end of the education, it was understood from the metaphor or metaphor explanations given by many participants that correlate is important in STEM.

STEM education aims to improve individuals' search for solutions by identifying world-related problems and linking them to real life (Bybee, 2013; Murphy, MacDonald, Danaia & Wang, 2019). Therefore, in STEM, correlate is very crucial in terms of collating information. The increase in the metaphors created shows that teachers realize that the association is important in STEM education process.

In the pre-form related to 21st century skills, teachers created metaphors for the categories of technology, life skills, basic needs, change, learning, knowledge, association, production, problem solving, and career development in descending order. In the post-form, they created metaphors for the categories of basic needs, life skills, association, learning, technology, change, knowledge, problem solving and career development in descending order. When the metaphors and explanations of the teachers about 21st century skills in the pre-form and post-form are examined, it is concluded that the metaphors created in the post-form can be explained in more categories than the pre-form (Table 2). It can be concluded that participants consider 21st century skills necessary and essential for making sense of life as they created metaphors for the categories of basic needs, life skills, and association. Today, individuals are required to produce problem solving skills, provide creative, self-control, communicate and build social skills instead of performing daily ordinary tasks (Eryilmaz & Uluyol, 2015). This situation appears to be the basic necessities for 21st century skills to survive. At the end of the in-service education, it is concluded that there is an increase in the perception that teachers consider 21st century skills as a basic need and that they need to be acquired in order to make sense of life as the metaphors of the 21st century skills directed towards the categories of basic needs and life skills. In addition, at the end of in-service education, teachers created metaphors that revealed the necessity of 21st century skills.

CONCLUSION

The metaphors and categories obtained as a result of the research show that teachers created metaphors for their limited knowledge of STEM and 21st century skills before the in-service education, while they created more comprehensive metaphors for STEM and 21st century skills as a result of their awareness and knowledge after the in-service education. In this context, in-service education, individual training and programs that teachers can actively participate in can be established to increase teachers' awareness interest in STEM and 21st century skills.

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