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# Pre-Service Science Teachers' Cognitive Structures Regarding Science, Technology, Engineering, Mathematics (STEM) and Science Education *

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## ABSTRACT

The aim of this study is to reveal pre-service science teachers' cognitive structures regarding Science, Technology, Engineering, Mathematics (STEM) and science education. The study group of the study consisted of 192 pre-service science teachers. A Free Word Association Test (WAT) consisting of science, technology, engineering, mathematics and science education concepts and semi-structured interview records were utilised to reveal their opinions regarding these concepts and inter-conceptual relations were used as data collection tools. While the WAT was implemented with all of the pre-service teachers, semi-structured interviews were carried out with only eight of the pre-service science teachers. Using two data collection tools via triangulation, enabled the researchers to obtain similar and varied findings. According to the frequencies, WAT was analysed using the cut-off point (CP) method; hence, concept network maps were composed and interviews were descriptively analysed. The findings of the study revealed that pre-service teachers' cognitive structures involved STEM disciplines and science education were quite independent from each other. Also, they could not make a distinction between science concept and science education concept, nor associate 'technology, engineering and mathematics' concepts with science and science education' concepts.

**Keywords:** Cognitive Structure; Pre-service Teachers; STEM; Science Education; Word Association Test.

## INTRODUCTION

Knowledge production and innovation have become more important than ever before for various countries since the last century. Moreover, it has become the biggest power factor for those countries. The USA, in particular, and many other countries realized how knowledge production and its contribution to development was exhibited when Russia launched the Sputnik. Then, these countries embarked on education reforms in order to keep up with the changes and developments taking place in the rest of the world (Laugksch, 2000). The most important of these initiatives has been in science education. First of all, it was found in the USA that more attention should be given to science education and that everybody should be science literate (American Association for The Advancement of Science [AAAS], 1990)

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However, as change and development continued rapidly in this period, the growth of scientific knowledge has brought about the development of technology and many disciplines. Considering the situation in recent years, these changes have led the structure of the problems encountered becoming more complex because change and development have become the source of the complex problems that are societal, environmental, economic and social. In this case, it has become a necessity to raise individuals who can cope with these problems, so the necessary skills individuals are required to gain have increased and become more complex. Therefore, this requirement has revealed the importance of science education. Primarily, it was stressed that science education was not enough, so knowledge in science-technology-society and environment should also be acquired (Deboer, 2000; Hollenbeck, 2006). However, it is regarded that these areas are still not enough to keep pace with the change. Especially because it was stated by the educational policy makers and educational researchers that interdisciplinary relationships are important and carrying out implementations in only one discipline in science education would not serve either national of global purposes and this has been emphasized in many research reports (e.g., NRC, 2012; Alberta Education, 2007). Furthermore, the STEM education approach, which is based on the integration of science, technology, engineering and mathematics (STEM) disciplines, is involved in education reforms and implementations have been increasing rapidly.

Similarly, when Turkey's science education goals are examined, it is possible to see the same goals and efforts. The purpose of science education is to have individuals gain life skills, which will bring solutions to the problems they encounter in their daily life, and to develop their scientific literacy levels (MEB, 2013). To achieve this goal, education systems and environments should be reorganized for the individuals to keep up with the changes and developments in order to make contributions to them. Because of the information that an individual is required to acquire, both in the knowledge and skill dimensions, in the science curriculum, which was revised in 2013. Moreover, as in the international reports, the reports which were prepared regarding Turkey's vision for the year 2023 and educational policies reveal that STEM education should be defined on our country's scale (Çorlu, 2014). Although technology and mathematics are not integrated into Turkey's science education, they are included in science education. But, the integration of engineering into science education is a new idea. In this direction, it seems very early to mention education standards determined for K-12 engineering education or learning outcomes, as defined regarding disciplines in the national context. In addition to this, STEM research studies are very rare in the studies, which have been carried out in Turkey (Bozkurt, 2014; Ercan & Şahin, 2015). But in the Report on STEM Education in Turkey (Akgündüz, Aydeniz, Çakmakçı, Çavaş, Çorlu, Öner et. al, 2015, p.20), it was emphasized that STEM education is a necessity for Turkey. For this reason, teachers in particular and pre-service science teachers, who will be the teachers in the near future, should be trained for the adoption and implementation of STEM education. This is a new teaching approach in Turkey, so they should be supported because a qualified science teacher should be aware of scientific developments and changes which will occur in the light of these developments and they should have the knowledge, competency and qualifications to aid their students to gain knowledge, skills, attitudes and values in this field. In order to actualize this, teachers and pre-service teachers, who are going to use STEM education in their lessons, should understand STEM disciplines and nature very well because teachers transfer their understanding and perceptions to their students (Palmquist & Finley, 1997). Therefore, revealing the pre-service teachers' cognitive structures regarding STEM and science education is important in the development of a course and for the transfer their understanding to the students regarding the following issues: how they understand or conceptualize STEM disciplines, how they are required to conceptualize them, how they establish relationship between these disciplines and how STEM disciplines will be integrated into science education. Therefore, it is important to examine their cognitive structures (for STEM and science education). It is thought that the results of this study (the cognitive structures of pre-service science teachers) will provide guidance on teaching intervention. Then, with information regarding these interventions, teachers can develop knowldege and skill in the STEM disciplines. Also, the cognitive structure of pre-service science teachers represents their perceptions of the integration of the STEM disciplines.

Cognitive structure is a form of structured information and shows the relationship of concepts in memory (Shavelson, 1974). Although it is difficult to explain an individual's cognitive structure, their ideas about key concepts provide important data to discover their cognitive structure (Gilbert, Boulter & Rutherford, 1998). Moreover, revealing cognitive structure does not only discover an individual's conceptual knowledge, or ideas, but also it helps them to understand the transitions between concepts and relationships (Tsai & Huang, 2002). Pre-service teachers' cognitive structures regarding STEM disciplines and their conceptual understanding are important when considering their teacher training.

In this regard, the purpose of this study is to reveal pre-service science teachers' cognitive structures and their understanding of STEM disciplines and science education. Regarding this purpose, answers will be sought for the following questions: "What are the pre-service science teachers' cognitive structures regarding science, technology, engineering, mathematics and science education like?" and "What kind of relationship do the pre-service science teachers establish between STEM disciplines and science education?"

## METHODOLOGY

Phenomenology, which is one of the qualitative research methods, was used in the study to describe the existing situation. Phenomenological design focuses on the phenomenon or particular situation which we are aware of but where we do not have in-depth and detailed understanding. In phenomenological design studies, the purpose is usually to reveal individual perceptions related to a phenomenon and their interpretations (Yıldırım & Şimşek, 2011).

The study group of the research consisted of a total of 192 pre-service science teachers (freshman N=51; sophomore N=52; junior N=44 and senior N=45) in the Department of Primary Education, Faculty of Education, in a middle-sized state university in the northeast of Turkey. The study was carried out during the fall term of the 2013-2014 academic years.

### a) Data collection

The data of the research study was gathered via the Word Association Test and semi-structured interviews.

#### *Word Association Test* (WAT)

The techniques used for the investigation of cognitive structures are free word associations, controlled word associations, topic trees, concept network maps, and flow charts. This study used a free word association test (WAT), which is one of the methods used to reveal individuals' cognitive structures and the relationship between the concepts in this structure and to determine whether the relationship between the concepts in the long-term memory are adequate and meaningful (Snow & Lochman, 2012:8; Bahar, Johnstone & Sutcliffe, 1999); it has been used by many researchers (e.g. Ercan, Taşdere & Ercan; 2010).

When planning a WAT, the following points should be considered carefully: each concept, which is related to the subject should be put on separate pages, if they are on the same page, they should be displayed consecutively and at least 10 times, and a space next to the word should be given for pre-service science teachers to write down the concepts that come to their minds. Bahar and Özatlı (2003) explained that the reason why the key concepts were written one under another was to prevent students from moving away from the key concept.

While implementing a WAT, students are asked to write the concepts they recall associated with any concept, consecutively, regarding their cognitive levels between 30 seconds and one minute and the reasons are explained like this:

> *It is stated in the literature that an ordered response given for any key word by a student from his long-term memory asserts relations between the concepts in his cognitive structure and this shows semantic proximity. Regarding semantic proximity or semantic distance effect, if the two concepts are very close to each other in terms of distance, they have a very close relationship in semantic memory. Moreover, during the recalling process, because cognitive investigation will be much faster, the responses associated with both concepts will be much quicker* (Bahar & Özatlı, 2003).

The WAT in this study includes five key concepts from science, technology, mathematics, engineering and science education. Each concept was written one under another and repeated 10 times on one page and a page layout was designed as shown in the example.

- Engineering…………………
- Engineering …………………
- Engineering ………………… (10 times)

During the implementation of the test, the pre-service teachers were asked to write the related words they recalled about the given key concepts in 40 seconds and the time was controlled by the researchers. At the end of 40 seconds, the students were asked to move on to the next key concept and the test was completed in that way.

***Semi-Structured Interviews***

Semi-structured interviews were carried out with eight pre-service teachers, two volunteer teachers from each grade. The aim of the interviews was to reveal pre-service teachers' views regarding how they explained and associated "science, technology, engineering, mathematics, and science education concepts". Each interview consisted of six questions. The first researcher carried out the interviews face-to-face and individually and each interview lasted approximately 10 minutes.

### b) Data analysis

For the analysis of the responses obtained from the word association test, the total number of the responses given to each stimulus word, whether the given responses had a relation with the stimulus and the overlapping between the response lists, which was a measure of semantic proximity between the two stimulus words for an individual, must be taken into consideration (Preece, 1976). Concepts that are created in this context are associated with the other concepts to give the integrity of the cognitive structure and concept networks are composed (Tsai & Huang, 2002).

In this study while the WAT was analysed, the concepts written by each pre-service teacher for each key concept were determined one by one and a frequency table was composed to determine how many different responses were given and how many times these responses were repeated for which key concepts. The Cut-off Point (CP) technique suggested by Bahar et al. (1999) was used to elaborate and evaluate the concepts, which were associated with key concepts in concept network maps. In this technique, in the frequency table, fewer than 3 or 5 words for the most frequently given response word for any key concept in a word association test was used as a cut-off point and the responses were found to have higher frequencies than this response frequency were written in the first part of the network map.

Then, the cut-off point was periodically decreased and the process continued until all the key words appeared on the network map. Because of the large number of participants in this study, the cut-off point was determined to be 40 and the concept networks were composed with a 10-frequency interval. As the cut-off point increased, the frequency of repetition of the concept decreased and this means that its frequency reduces. Therefore, the evaluation was that very few participants recalled that word.

Semi-structured interviews were firstly transcribed and then they were analysed descriptively. The pre-service teachers, who were interviewed, were coded in order as, PT1 (first pre-service science teacher), PT2, PT3, PT4, PT5, PT6, PT7, and PT8 and their views were presented. For supported word associations, the results presented the interested views of the pre-service science teachers as quotations.

In order to provide the validity of the results, two researchers conducted the analysis and network maps were created as common. The process of analysis was explained in detail; also the findings were supported by quotations from the interviews.

## FINDINGS

This section includes the findings, which were obtained from the analysis of the data collected via the data collection tools and these findings were supported by the views of the pre-service science teachers.

Generally, the first cut-off point (CP) was determined to be 40 and above, to create a concept network map. The following cut-off points were decreased three times. The concept network maps for each cut-off point level are given below.

Figure 1 presents the repeated concepts that were determined as 40 and above, regarding STEM and science education.

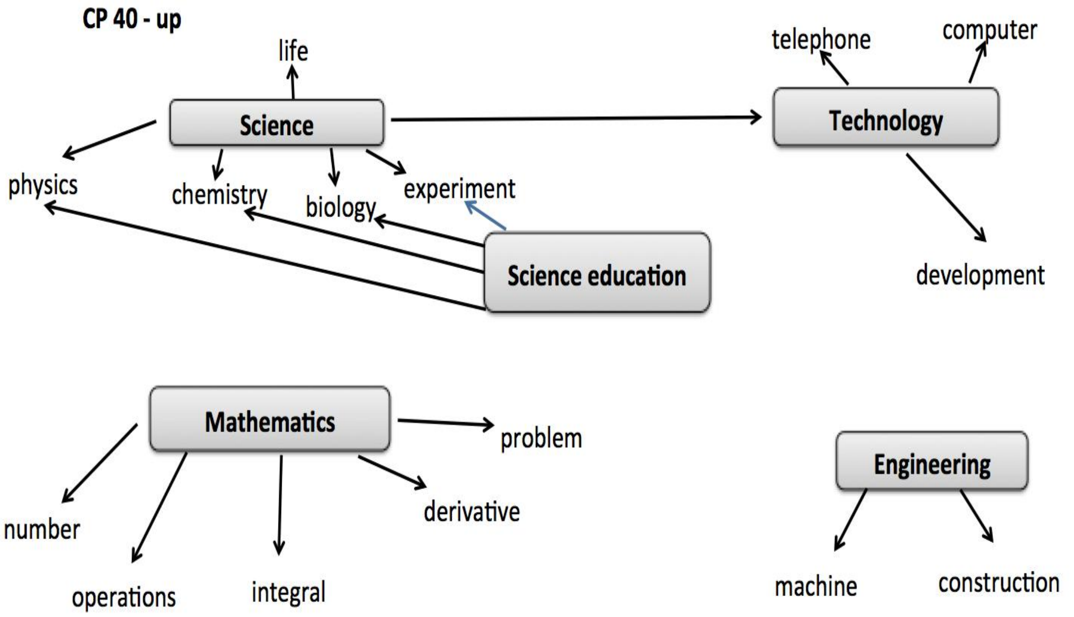


**Figure1.** *Concept network map created for the concepts with a cut-off point of 40-upwards*

When Figure 1 is examined, it is seen that in the concept network map, which was created with CP 40 - upwards, shows that the pre-service teachers associated science with life, physics, chemistry, experiment and technology concepts, they associated mathematics with numbers, operations, derivatives, integrals and problem concepts; technology was associated with science, development, computers and telephone concepts; engineering was associated with machines and construction concepts; and finally, science education was associated with physics, chemistry, biology and experiment concepts.

Similarly, PT2 explained their views on science, as *"…Science explains the events happening in our life. For example, how we stand on the Earth. This is physics, chemistry, and biology… In fact, it is everything…"*. PT6 explained their views on technology, as *"… technology covers all of the gadgets and tools which we use, like computers, tablets, telephones, calculators…. all these things were created by using science… "*. PT7 explained their views on mathematics, as "*Mathematics is derivative, integral, operations, geometry, trigonometry, and limited. It is about calculation.…"* PT 4 explained their views on mathematics, as *"Science education is the teaching of science, chemistry and biology to students by the teachers…"*.

It was found that pre-service teachers were unable to establish a relationship between science education, technology, engineering and mathematics concepts. Also PT6 explained their views on engineering, as *"Engineering is construction, food, electricity, trade, machines and computers. Usually, they draw and introduce what they are going to produce. The other workers do what they draw. …. A food engineer focuses on how food is processed with which technique."*

Figure 2 presents the repeated concepts that were determined between 30 and 39, regarding STEM and science education.

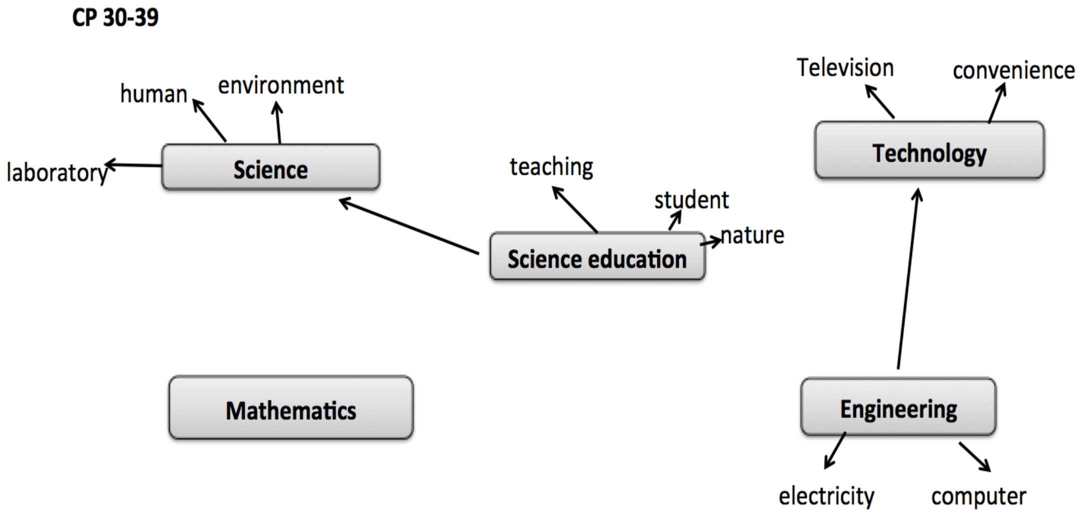


**Figure2.** *Concept network map created for the concepts with a cut-off point of 30 -39*

When Figure 2 is examined, it is found that, in the concept network map created with CP 30-29, the pre-service teachers associated science with environment, human and laboratory concepts; technology with television and convenience concepts; engineering with technology, electricity and computer concepts; and science education with science, nature, teaching and student concepts and they were different from the concept network maps formed at higher cut-off points.

Similarly, PT8 explained their views on the network of engineering and technology, as *"… technology enables us to do our work easily without it becoming too difficult. To exemplify, telephones, computesr, and television facilitate communication. In fact, lifting jacks, bulldozers, and load pullers in construction are the technologies used by engineering…"*. PT5 explained their views on network mathematics and technology: *"…mathematics is numbers and operations. It helps us to calculate something. In fact, we can say that it is not only calculation… It is all of the tools we use, like computers, tablets, telephones, calculators … these are the things, which are created by using science…"*. PT2 explained their views on science education, as: "*Science education is whatever science is… "*. Also, PT4 explained their views on engineering, as:*"Engineering is what engineers do. For example, a civil engineer constructs buildings, an electrical engineer works on power* *connections, a mechanical engineer designs and develops machines."* Also, PT3 explained their views on the networks of all concepts *"...I think that there is no relation between engineering and science or science education.... Engineers use technology and mathematics. In other words, they are similar...".*

Figure 3 presents the repeated concepts that were determined between 20 and 29, regarding STEM and science education.

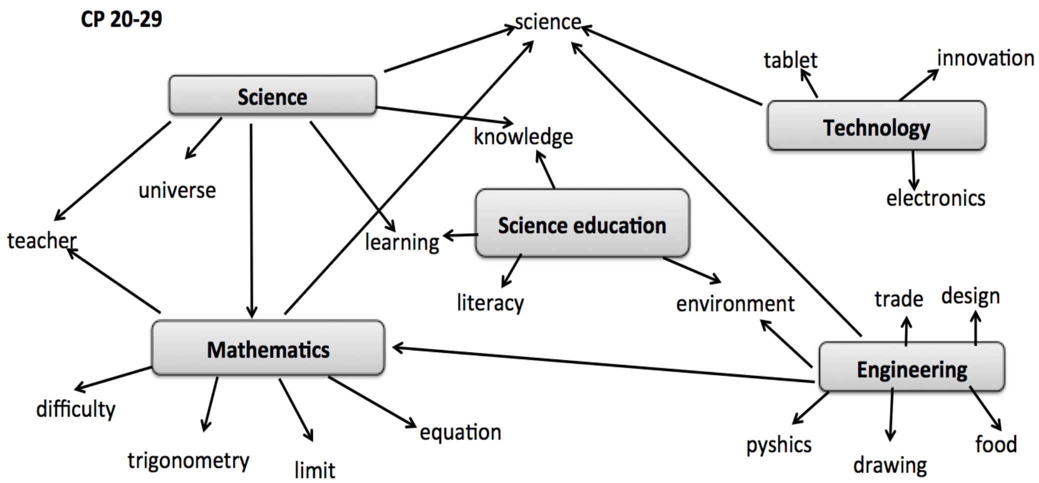


**Figure3.** *Concept network map created for the concepts with cut-off point 20 -29*

When Figure 3 is examined, the concept network map created with CP 20-29, reveals a different pattern from the concept network maps, which were formed at higher cut-off points. The pre-service teachers associated science with learning, knowledge, teacher, and universe concepts; technology with science, tablets, electronics and innovation concepts; engineering with the concepts of trade, design, food, drawing, physics, mathematics and environment; mathematics with concepts of difficulty, trigonometry, limits and equations, and science education with knowledge, learning, literacy and environmental concepts. Moreover, while science was associated with mathematics directly and with teacher concepts, science education was associated with knowledge. In addition, it is observed that engineering was associated with science education and environment, and directly with mathematics and science.

Similarly, PT2 explained their views on matematics, as *"...mathematics is used in science, technology and engineering to lift the materials to be used for construction. But people are not aware of it..."*

Figure 4 presents the repeated concepts that were determined between 10 and 19, regarding STEM and science education.

When Figure 4 is examined, it is found that from the concept network maps formed at upper cut-off points, the concept network map formed with CP between 10 and 19 associated all of the concepts with more concepts. While the pre-service teachers associated science and technology with microscopes, they established a relationship between science and science education with observation concepts. Technology was associated with science education and with benefit concept. Engineering and science education were associated with the concept of school. Moreover, mathematics was associated directly with technology and science education was associated with lesson concept.

PT1 explained their views on network of all concepts, as *"...We use technology while teaching science. We also perform arithmetic operations..."* Also, PT8 explained, *"We teach science in science education. We can also use technology. But, scientists use science to discover technology. Engineers use technology, too. Mathematics is used both in engineering* *and mathematics. But, engineering is not used in science education. Maybe it can be given as an example from daily life. As I said before, a forklift truck used to lift and move materials to the construction and standing in the balance can be a daily life example when explaining equilibrium. In fact, all of them are related to each other. But this relation is not an indispensable relation.".*

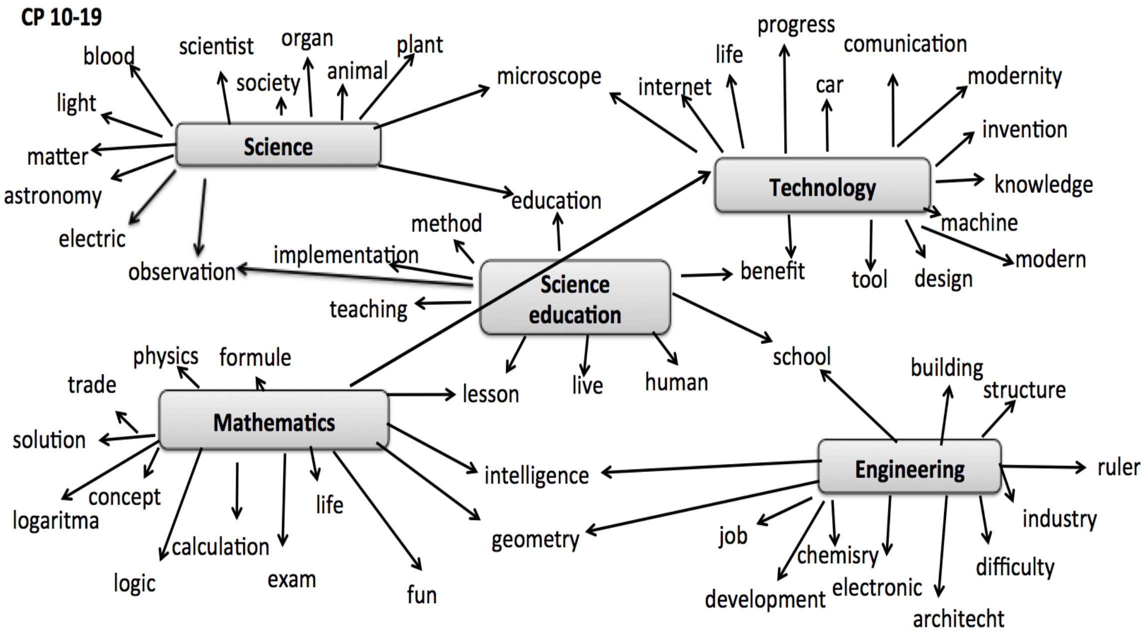


**Figure4.** *Concept network map created for the concepts with a cut-off point of 10 -19*

## CONCLUSION and DISCUSSION

It is important to understand the nature of individuals' opinions in order to discuss their views about science and learning effectively (Finson & Others, 1995; McDuffie, 2001). The ideas of students who have the required qualifications to become a scientist in the early periods of their education and who generate opinions about science and learning, frequently depend on the messages received from out of school settings (Jones, Howe & Rua, 1999). At the end of the study, the pre-service science teachers' statements obtained from both the WAT and the interviews, revealed that they could not adequately differentiate between science and science education and they explained them as physics, chemistry, biology, experiments, learning and nature. The Turkish Language Association defined science as "the common name given to physics, chemistry, mathematics and biology", and the "implementation of data obtained from physics, chemistry, mathematics and biology at work and on a building site." (URL). Similar expressions to this definition were encountered with the pre-service teachers' views. Events and phenomena we encounter in our life, are closely related to science. Science depends on the generalizations attained as a result of the investigation of nature and an attempt to predict events, which have not come to light yet, observations and experiments. While the pre-service teachers were describing science in the interviews, they defined it as the investigation and understanding of all the events and phenomena in our life and, similarly, they expressed science education as the teaching of it. Moreover, when pre-service teachers' cognitive structures regarding science and science education were examined, they associated science with the content knowledge of science education (cells, electricity, human beings, etc.), with the environment, which they use while learning or teaching science (laboratory, class, etc.,) and with some equipment and tools they use (microscope).

Technology makes our lives easy with the materials developed, thanks to the combination of knowledge and concepts obtained from different disciplines, such as science, mathematics and culture (Doğru & Şeker, 2012). In other words, it cannot be thought of as inseparable from other disciplines. However, it was revealed that pre-service teachers explained technology as electronic tools and the convenience they gave, as well as the development, and they did not associate technology with many other disciplines. Çepni, Ayas Akdeniz et al. (2005:7-8) defined the goals of technology and they focused on facilitating life and its stresses, which should be done according to the laws of nature. Moreover, other studies revealed similar results and found that individuals recall technological devices when talking about technology and they tried to define technology with these products (Durukan, Hacıoğlu & Dönmez-Usta, 2016).

It is important to understand the relationship between science, technology, other disciplines and society and the results of this relationship, in order to achieve the goals of science education (Hançer, Şensoy & Yıldırım, 2003). One of the other disciplines is mathematics. There is no science field where mathematics is not used, but it is mostly used in physics and science (Aksu, 2008). In STEM education, mathematics is as important as the other disciplines in terms of the skills, which individuals are required to gain. Thus, mathematics should be defined as knowledge, skills, beliefs, dispositions, habits of mind, communication abilities and problem-solving skills, which an individual needs in order to engage effectively in quantitative situations occurring in life and work (MCATA, 2000).

However, it was revealed in this study that pre-service teachers defined mathematics as numbers and operations. On the other hand, stood out in the interviews was that there were some pre-service teachers who explained mathematics with regard to target goals and who explained its importance and how it was used with other disciplines. But, there were no pre-service teachers who expressed concepts or views regarding mathematics' relation to real life. Thus, because it is important to develop an understanding of the cognitive structures of pre-service teachers who are going to give STEM education, considering the nature of mathematics and mathematical literacy, it was revealed that there is a strong need to be in communication and cooperation with these teachers working in this discipline. It is important to discover individuals' and students' views on the engineering discipline to understand their views on the engineering profession and to develop career awareness related to the STEM education approach (Knight & Cunningham, 2004). Engineering is defined in the literature as a complex initiative, which generates achievable solutions via using creativity, science and mathematics in order to meet the needs and desires of people (Wulf, 1998) and a profession which has a problem-solving process (Petroski, 1996). It is emphasized in the study of Petroski (1996) and in the reports published by NAE (2010) and NAGB (2010), that design is very important in the process. Pre-service teachers mostly explained engineering as machines, construction and the product of professions related to electronics in this study and, similarly, it was found in the literature that students stated that engineering was related to mechanics (Oware, Capobianco & Diefes-Dux, 2007). Moreover, many research studies have stated that many pre-service science teachers' perceptions of engineering and the engineer, focus on engineering products and engineering branches (Marulcu & Sungur, 2012). It can be stated that daily experiences and the environment have an important effect on the rise of this condition. Although there are a lot of engineering products around us in daily life, students, teachers and pre-service teachers do not understand what engineers usually do (Frehill, 2007). Knight and Cunningham (2004) stated that students, who were aware of studies on engineering, obtained most of the information from sources like the media. Therefore, the importance of teacher training cannot be ignored to prevent this limited perception, which will occur within the students, the founders of the future. Thus, these results may be a guidance to explain the nature of engineering, so that this limited perception of the pre-service teachers can change and they can understand STEM education.

Understanding STEM disciplines and the relationship between STEM and science education is important in order to keep up with the times. The findings of the study revealed that while there was a strong relationship between the pre-service teachers' cognitive structures and science and science education, there was a weak relationship between science and technology, technology and engineering and mathematics and science, and there was scarcely any relationship between science and mathematics. In fact, although the relation with mathematics is stressed in science education curricula, pre-service teachers could not express this relation with the concepts in the word association test. However, in the interviews they expressed their opinions regarding the importance of mathematics, in order to learn particularly physics and chemistry from science disciplines. They stated these views as if mathematics existed in the nature of science. This result supports the fact that pre-service science teachers are unable to use the knowledge in their disciplines within the context of other disciplines (Çorlu & Çorlu, 2012).

Technology is an indispensable part of science (Ortakuz, 2006). But, in the literature it is revealed that in their cognitive structures, pre-science teachers can build a weak relationship between science and technology and this relationship is only at the level of technological product (Erduran, Avcı & Akçay, 2014); they could not easily distinguish between science and technology; they viewed technology as a sub-discipline of applied sciences; and what they understood from technology was only technological products (Aydın & Taşar, 2010). However, the individuals who were aware of the relationship between science and technology understood the effect of these disciplines on social life (Bridgstock, 1998). Moreover, when STEM was not popular, Science-Technology-Society-Environment was emphasised in the Turkish Science Education Curriculum (MEB, 2005) and students received training according to this curriculum. However, the pre-service teachers who received this education were not able to state any concepts in the WAT, considering these gains and also they could not mention this relationship in their opinions. On the other hand, Ayvacı and Şenel-Çoruhlu (2012) found different results in their studies from this study and stated that science teachers could not explain the relationship between science and learning technology independently and they considered science and technology concepts to be equal, but not science and learning. This concept of considering science to be equal with the other disciplines was called "Myths of Science" by Mc Comas (2000). It can be interpreted that the existence of this condition within pre-service teachers and students can result from the fact that these concepts are used wrongly or interchangeably in daily life. Moreover, it can be stated that the definitions of these concepts have a similar situation in the dictionary of the Turkish Language Association and the people who read these definitions in this dictionary may have misconceptions about these concepts (URL).

Ayvacı and Şenel-Çoruhlu (2015) determined in their studies that teachers used technology in their lessons with the purpose of introducing the importance of technology for the society and signifying its effects on our life. Although the pre-service teachers mentioned technology to teach science in this study, what drew our attention was that there were no concepts related to technology in the word association test. This result shows that pre-service teachers should acquire technological pedagogical content knowledge (TPCK) to use educational technologies for STEM education (Grable, Molyneux, Dixon & Holbert, 2011). Moreover, the function of the technology discipline, mentioned in STEM education, does not only involve educational technologies. It should be addressed as the production of technology, the use of and the development of technology. Therefore, it is very important to understand the nature of the disciplines in STEM education and, at this point, it is a requirement that pre-service teachers and teachers should be trained. These results may lead to training being given to the pre-service teachers.

In the Turkish science education curriculum (MEB, 2013), the gains intended for the engineering discipline and engineering design process are not included under the name of the discipline, but under the knowledge and skill gains. But, it was revealed in this study that the pre-service science teachers could not build a relationship between science education and engineering in their cognitive structures and views. It was found in the literature that students and pre-service teachers could not explain the meanings of science, technology, engineering and design concepts and they could not associate between these concepts (Hsu, Purzer & Cardella, 2011). Indeed, cognitive structures towards engineering, perceptions and ideas have an effect on students' attitudes towards technology and science (Knight & Cunningham, 2004). It is thought that a negative attitude towards science will also indirectly lead to a negative image regarding engineering (Sherriff & Binkley, 1997).

When the literature which examined individuals' views on engineering was examined, it was found that as many people, including teachers, did not have enough information about engineering (Akaygün & Aslan-Tutak, 2016), and its impact on society, and it was ineligible in students' career choices (Kimmel, Carpinel & Rockland, 2007). When considered from another point of view, even if no one chooses a career in engineering in developed societies; everyone has to have science literacy, technology literacy and engineering literacy. Furthermore, it was seen that students restricted engineering only to the concepts like mechanics and construction and they could not develop a positive attitude towards engineering (ASEE, 2003). The studies conducted determined that interdisciplinary science education, and particularly engineering design-based learning, were effective to eliminate these wrong perceptions and negative attitudes (Reynolds, Mehalik, Lovell & Schunn, 2009). Moreover, the implementation of pilot studies intended for engineering design-based learning increased the participant pre-service teachers' desire for integration of the engineering discipline into science education (Hacıoğlu, Yamak & Kavak, 2015).

In conclusion, the data of this study suggests that future teachers' cognitive structures regarding STEM concepts and science education concepts are independent of each other; especially their perceptions of engineering, which are far from their perceptions of science, technology, mathematics and, most importantly, science education. This study's results indicate that teachers, who can solve some 21st century problems and who aware of nature of disciplines and the relationship of disciplines, should be further educated. In accordance with these results, it is suggested that the science education curriculum, including STEM activitiesshould be further designed. It should be be given to teachers pre-service and in-service training about STEM education and especially EDBSE.

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