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The Effect of Stem Education on Pre-Service Science Teachers' Perception of Interdisciplinary Education

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ABSTRACT

In both Turkey and the other countries, disciplines in curricula emphasize interdisciplinary approach under the heading of "related with the other courses". STEM education is one of these approaches. One major problem faced by STEM education is the shortage of professional programs which guide teachers about the relationship between STEM disciplines and how to teach it in class. This study was carried out to investigate the change in pre-service science teachers' perspective of interdisciplinary relation after giving them pre-service education on interdisciplinary STEM education. Case study research model was used in the study. The study was conducted with 32 pre-service science teachers in the third grade in Recep Tayyip Erdogan University, Faculty of Education during the fall semester in the 2015-2016 academic year. In the scope of this study, science pre-service teachers were given pre-service education on interdisciplinary STEM approach; pre-test and post-test data were collected by applying the STEM-WAT and STEM surveys to the participants; and the collected data were analyzed with descriptive analysis. According to the pre-test results, the participants were able to relate science education to various disciplines prior to the STEM education. In the post-test results, despite a decrease in the number of disciplines related to natural sciences, an evident increase was reported in the number of relations with certain disciplines such as Mathematics, Technology and Engineering. Before the STEM education, pre-service teachers were thinking of relating teaching Natural Sciences to just Mathematics in their future classes. After the STEM education, they were reported to think of relating their teaching with Mathematics, Technology and Engineering. Moreover almost all pre-service teachers think of benefiting from relation of natural sciences with other disciplines in their classes. They thought that such relation would be useful for both individual and social development of students and instruction.

Keywords: Interdisciplinary Education; STEM; Pre-Service Education.

INTRODUCTION

Today, the economy of the world increasingly takes a structure based on knowledge, and countries continuously renew and increase their capacity to create innovation and technology in order to survive and obtain advantages in the global economy.

Turkey is also investing rapidly in industry and technology to increase competitiveness in this global race.

The success of countries in this area depends on a large number of qualified and well-trained personnel in Natural Sciences, Technology, Engineering and Mathematics, the STEM

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areas. As a result, we have to increase the number of successful students trained in the STEM areas not to lag behind in this race.

However, international and national assessments indicate that Turkish students have a lower level of performance in science, technology, engineering and mathematics fields and their interest in those areas is decreasing and they do not prefer these areas much for their future career (Marulcu and Sungur, 2012; Marulcu and Hobek, 2014, Url-1; Url-2). When the results of the Trends in International Mathematics and Science Study (TIMSS) status determination are analysed, Turkey was on the 33rd rank with the overall score among 38 countries when it first participated in 1999, then in 2009, it became the 42nd out of 55 countries, and lastly in 2015, Turkey was even below Greece on the 41st rank, which was facing with many crisis, among 76 countries (Url-3). Thus, Turkey cannot be said to be successful in TIMSS exam. Due to the significant relationship between attitude and academic achievement, we tried to find out at what extent this fact reflects on students' career choice. In a study carried out by Istanbul Aydın University (2014), distribution of the first 1000 students entering numerical fields between the years 2000 and 2014 was investigated by percentage of placement in STEM fields at university entrance exams. In 2000, the rate of placement in STEM fields was 85%, but it decreased to 27% in 2010, then increased to 38% back in 2014. Across all numerical fields in 2014, 81.39 % of the students who were placed in STEM fields were males, while the rate of females was only 18.61%. The failure of the students in STEM fields and the shortage of selecting the STEM professions reflect on economy. The research carried out by TUSIAD (Turkish Industrialists' and Businessmen's Association) (2014) shows that only 19% of the labor force in STEM fields in Turkey (manufacturing and network industries, retail and service sector) are comprised of individuals graduating from STEM fields (% 64 are males and 34% are females). In addition, according to the report, Turkey will face a crisis in STEM fields in the future, the labour demand in STEM areas will increase even more than in previous years within next 10 years. However, the demand will be hardly met with the existing or future labour force, so there will be a need to import labour from abroad (Koçel, 2004; Özsoy, 2015).

The interest in fields of STEM is described as positive approaches of individuals towards natural sciences, technology, engineering and mathematics subjects. Thus, this interest becomes an encouraging factor for these people to build a career in a field of STEM (Buxton, 2001). However, students tend to lose their interest in natural sciences, technology, engineering and mathematics fields until they reach high school and college levels. One reason for the loss of interest could be the discrepancy between in the dominant understanding of STEM education in primary education and secondary and high school. As students are inclined to perceive the outside world holistically, interdisciplinary teaching of STEM topics (Science of Life) is realized to some extent in primary education. However, it is mostly replaced by teaching of the same subjects (Physics, Chemistry, Biology, Geometry, Mathematics etc.) with a disciplinary approach rather than interdisciplinary at secondary and high school levels. It is a fact that human beings' attempts to find solutions to everyday life or their ways of communicating with others are not limited with the specific knowledge and skills about a particular discipline. Questions and answers asked in everyday life often fall under more than one discipline. Therefore, information and skills in the science or mathematics education may be unauthentic if not presented in such a context. Under these circumstances, it seems inevitable that students have da ifficulty in discipline-based teaching and eventually lose their interest in those courses (Yıldırım, 1999). The results of the above-mentioned STEM-related researches by Istanbul Aydın University (2014) and TUSIAD (2014) seem to be supportive of this case. In addition to this, interdisciplinary teaching can help solve this problem that could be brought by disciplinary education as it is more suitable for students' natural learning process and the way of perceiving the world (Harrel, 2010). It is emphasized in related literature that students' participating in activities where STEM subjects are discussed with an interdisciplinary approach makes the STEM topics more meaningful and increase the interest shown towards STEM fields at an early age (Dabney et al., 2012; Raju and Clayson, 2010; Tindall and Hamil, 2004). The research carried out by Dewaters (2006) revealed that students are satisfied with lessons in which STEM topics are discussed with an interdisciplinary approach and those lessons help to solve such problems in the course of daily life. Also, Bingölbali, Monaghan and Roper (2007) found out that implementation of project-based learning activities integrated with STEM has a significant effect on students' positive attitudes towards STEM and their future career choices. Maltese and Tai showed (2010) that senior students from secondary schools which perform STEM-based instruction have a three times higher tendency for orientation to STEM disciplines in the next period than those not having gone through such an education. As another example, Cho and Lee (2013) concluded that students' creativity (creative problem solving and creative personality) and learning levels improve as a result of the lesson plans developed according to STEM education. An essential feature of interdisciplinary STEM teaching is availability of learning activities dependent on problems or conditions. Learning abstracted from everyday life, which is one of the main characteristics of traditional science teaching, leaves its place to learning closer to everyday life in the context of STEM interdisciplinary teaching. In fact, many natural sciences subjects that students must learn in class have an interdisciplinary aspect. Suppose that interdisciplinary teaching is performed around the concept of "Electric Energy". Such a topic will be most likely to be interesting and important to students since it is closely related to their daily lives. In such an educational process, the topic of "Electric Energy" could be considered from various aspects and different disciplines could be exploited to support the teaching. For example, courses like Physics, Chemistry, Biology, Technology, Engineering and Mathematics may contain information related to this topic and such information can be taught within the framework of "Electric Energy" concept. . A conceptual structure based on this model that performed by the reserchers of this study seen in the Figure 1. Here, an exhaustive list of examples can be given for any sub-topic or questions that could be included under each discipline.

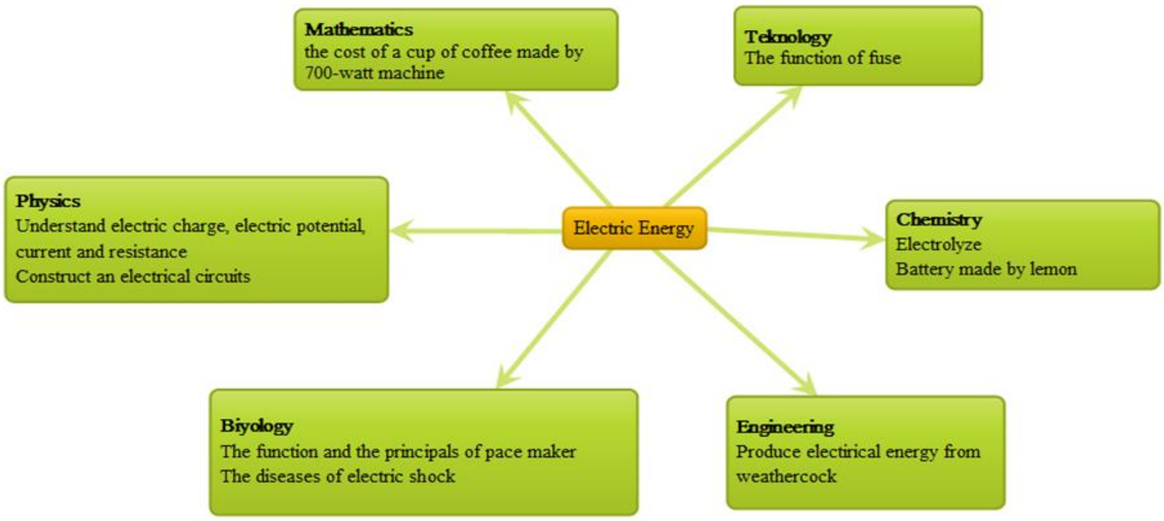


Figure 1: *Conceptual structure of electric energy with disciplines*

As seen in the figure above, students can receive STEM education based on an efficient and effective interdisciplinary approach naturally depending on the teachers' ability to relate their major to the knowledge and skills from other disciplines (Nadelson et al., 2013). According to Osborne et al. (2003), the quality of a teacher constitutes the most important factor in students' maintaining their career choice in STEM areas. However, as teachers are not often encouraged to relate their subject area to other disciplines, they just try to convey information to learners about their respective subjects, not attaching much importance to the extent to which knowledge and skills learned in these courses are applied to other courses or how they are associated with other courses. As a result, separate knowledge and skill groups are emerging in schools. Wang et al. (2011) argue that one of the major educational problems of the K-12 STEM education is the minimum amount of professional programs to guide or help teachers about the relationship among STEM disciplines and how to teach this relationship in the class. Research results about effectiveness of the STEM teaching curricula also support the above mentioned case. Researches demonstrate a number of obstacles to teachers' inability to associate their own fields with other areas (natural sciences, math, technology and engineering fields). These include a reluctant co-operation with teachers in other disciplines, teachers' inadequate information about effects of the STEM approach, teachers' not seeing the STEM approach as a method to increase students' achievement in their discipline, school's structural limitations, shortage of educational materials and so on (Pinell et al., 2013; Raju and Clayson, 2010; Nadelson et al., 2013; Shahali et al., 2015; Han et al., 2015; Siew et al., 2015). The result revealed that teachers learn more about the relationship among sciences, technology, engineering and mathematics disciplines, integrated STEM instructional strategies and STEM concepts, they feel more comfortable in teaching STEM (Nadelson et al., 2012; Stohlmann et al., 2013; Halim et al., 2014;). A professional development workshop approach for pre-service and in-service teachers is one way of creating teachers' awareness of science teaching through a STEM approach (Han et al., 2015). In this regard, the present study intends to reveal the changes in pre-service science teachers' perception of the relationship among natural sciences, technology, engineering and mathematics disciplines as a result of the STEM education program developed for them.

METHODOLOGY

This study, which intends to determine whether the STEM education helps pre-service science teachers comprehend the relationship among natural sciences, technology, engineering and mathematics, was conducted as Case Study. This research method was preferred in order to study one single variable deeply instead of a limited number of variables, to gather the data from the environment in a systematic way, and to provide an understanding of what facts need to focus in future research owing to the outcomes (Cepni, 2007). During implementation of the study, pre-service science teachers were given an education based on an interdisciplinary STEM approach. Both before and after the education, the STEM Word Association Test (STEM-WAT) and STEM Survey were administered as a pre and post-test data collection tool. The obtained data were analyzed with descriptive analysis method.

a) The Programme of Pre-service Education

STEM education course is a 9-week pre-service education programme developed by the STEM Coordination of Recep Tayyip Erdoğan University (RTEU-STEM) for pre-service science teachers. The course was carried out in the RTEU-STEM laboratory from November 16, 2015 to January 8, 2016. The purpose of the STEM Education was to emphasize the relationship and integration among natural sciences, technology, engineering and mathematics disciplines so as to create a familiarity among pre-teachers with the STEM approach, to ensure an in-depth understanding of the relationship among STEM disciplines, and to develop a positive attitude and belief for the use of this relationship in future science teaching classes. During the education programme, the participants in groups of four participated in five sessions involving Suspended Bridge Design, Amusement Park High-speed Train Design, Cockhorse Programming, Shopping Mall Door Design and Communication Technology Design comprising of activities in compliance with problem-based teaching method. Also in the scope of Free Activity Design, they developed engineering design models to address their own set of problems and exhibited these models in the exhibition hall of the faculty for the other teachers and students from their own department. In these events, engineering design process was used as a teaching strategy to establish the relationship among the disciplines of natural sciences, technology, engineering and mathematics (See Appendix 1 for sample activity plans and problems).

b) Participants

The study was carried out with 32 third-grade students taking the Instructional Technology and Material Development course in Department of Science Teaching, Faculty of Education at Recep Tayyip Erdogan University during the fall semester in 2015-2016 academic year. The data collection instruments were applied to the 42 students registered in this course. Some of the respondents just answered the pre-test, while some others answered the post-test only; some others did not answer the surveys completely. To obtaine meaningful data, the answers given by 32 participants that attended the course and answered the whole survey were analyzed. The demographics of these participants are listed below in the Table 1.

Table 1: *Demographic characteristics of participants*

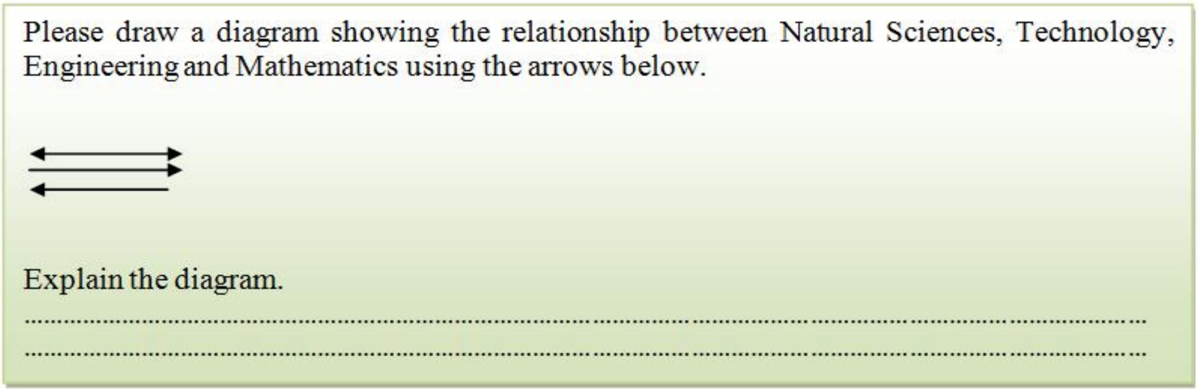
Demographic characteristics		n	%
Gender	Female	21	66
	Male	11	34
Type of high school graduated from	Science high schools, Anatolian high school, Super lycee	6	19
	General high school	22	69
	Vocational high school	4	12
The rank among the choices in the SPE (Student Placement Exam) exam	1-3	15	47
	4-10	10	31
	11-30	6	19
	Not remember	1	3
The field in the high school graduated from	Numerical	28	88
	Equal Weight	2	6
	Verbal	2	6
The level of self-confidence in science teaching	Very high	3	9
	High	20	63
	Medium	8	25
	Low	0	0
	Very low	1	3
The level of enthusiasm for science teaching	Very high	14	44
	High	13	41
	Medium	4	12
	Low	0	0
	Very low	1	3
The level of interest while studying science	Very high	5	16
	High	15	47
	Medium	11	34
	Low	0	0
	Very low	1	3

c) Data Collection Instruments

In this study, STEM Survey and STEM-WAT which were developed by the resarchers of this study were used as data collection instruments.

The STEM survey consists of 5 pre-test questions and 7 post-test questions. The scope of these questions is the ability to relate natural sciences to other disciplines, as well as to evaluate the STEM education offered. Data analysis was performed on the answers given for three relevant questions. The open-ended questions included "the other disciplines they could relate to natural sciences discipline", "whether or not they are thinking of using the relation between natural sciences discipline and other disciplines in the context of science teaching lesson" and "Please describe the relationship among Natural Sciences, Technology, Engineering and Mathematics disciplines by using arrows". These questions were selected assuming that they directly serve the purpose of this study. Moreover, to enhance reliability of the findings, the question "What is natural sciences?" was investigated in terms of the relation with the disciplines.

The open-ended question requiring respondents to describe the interdisciplinary relations with arrows is as the following in Figure 2:


Please draw a diagram showing the relationship between Natural Sciences, Technology, Engineering and Mathematics using the arrows below.

Explain the diagram.

…………………………………………………………………………………………

…………………………………………………………………………………………

Figure 1: *The last question of the STEM Survey*

As seen from the Figure 2, the respondents were asked to make drawings and provide an explanation about the diagram. Attention has been paid to participants to draw and explain the diagram. Forty-five seconds were given for answering the question.

The word association test (WAT) shows the number of response words produced for each keyword before and after teaching. In this technique, the number of response words produced for each keyword is one of the first methods used to evaluate the data (Shavelson, 1974). The number and quality of words given by students for each keyword can determine whether or not the concept was understood by looking at the number of responses given for the keywords in the memory (as response words increase, it can be said that understanding increases, too), and word type (whether it is related to the keyword) (Bahar, Nartgün, Durmuş and Bıçak, 2006).

The word association test (WAT) on each page contains keywords, and respondents are expected to write the words recalled by each keyword in the gap at the bottom of the keywords. In this study, the keywords selected in pre-test in the STEM-WAT were chosen as Natural Sciences, Technology, Engineering and Mathematics keywords. The keyword of STEM was added in the post-test. A sample page layout used in the implementation is given below in Figure 3:

Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---
Natural Sciences ---

Figure 2: *A sample page layout used in WAT*

The students were provided with descriptions regarding the WAT, and thirty-five seconds were given for each of the concepts. Then, the students wrote the words thought to be associated with the keyword. The keyword was written under the other one leaving a blank to prevent the risk of a chain response (Bahar and Özatlı, 2003). If the respondent does not return the keyword while writing each word, they can write the words brought to mind by the concept provided as response, instead of the keyword, which may interfere with achieving the objectives of the test. The time given to the students for the keywords in every page was checked. At the end of the allotted time for each keyword, the students were asked to go to the other concept, and the operation was repeated until all keywords are run out.

d) Data Analysis

The first three questions in the STEM Survey were analyzed with content analysis, while the last question was analyzed with classification of the drawings. During content analysis; the transcribed version of the interview was examined several times, important dimensions were determined considering the literature for the purposes of this research, and codes were generated from those dimensions. As a result of examination of the generated codes, their relations with each other were elicited and classified, and the common themes were found. These transactions were made with Nvivo package program. The compliance obtained from analysis of the data separately coded by two researchers was compared for reliability of the coding. Also, since the interview data were turned into a research report initially on the basis of description of the current situation, direct quotes were used in order to reflect the perspectives of the participating students and to portray the described situation more vividly in the mind of the reader. In addition, pseudonyms (P1, P2, …., P32) were replaced with the participants' real names in order to hide their identitis.

The STEM-WAT was analyzed by examining in detail the responses given for the word association test in the pre-test and the post-test. First, the frequency table was prepared to indicate how many different words were used by students for natural sciences, technology, engineering, mathematics and STEM keywords. The number of generated response words is one of the methods used in the evaluation of the data in this technique. The number and nature of words associated with a concept can be used to determine if that concept was understood because a better understanding of the concept depends on other words associated with it. Then, the frequency of the words used for each keyword was calculated. For analysis of the WAT results, not only the frequency and types of the key words but also the number of common words allocated for key words and the order of listing them are also important. This in turn helps to analyze the semantic proximity between keywords and allows us to map it. The mapping can also be made using data in the frequency table. Bearing these frequencies in mind, separate concept networks have been formed for pre-test and post-test. While creating the concept networks, the cut-off point (CP) technique developed by Bahar et al. (2006) was used. In this technique, initially the most frequently mentioned response is determined for each. The frequency of the response is considered to be the upper limit. 3-5 points below the highest frequency is used as a cut-off point. Determined cut-off points are written on the left side of the table. Concept networks are created starting from the first cut-off interval. Then, the cut-off point is pulled down at regular intervals and the process continues until all of the keywords appear in the concept network. In this study, the upper limit is set at 26 and above, and the concept network is created as 5 interval starting from here. The relations occurring at each cut-off interval are shown in different colours. Each interval drawn in the analysis phase of the data was examined individually because the answer word related to the keywords can be a product of connotation at the level of recalling with a non-significant relationship with keyword (Nartgün, 2006). Also, the interval will be more complex and upper level than a single-word answer.

FINDINGS

The results are presented in two sub-headings as the results obtained from the word association test and those obtained from the survey. The first sub-headings is devoted to the survey results regarding pre-service teachers' thoughts on relations between natural sciences and other disciplines. Under the second sub-heading, the findings obtained from the word association test showing the pre-service teachers' cognitive structures related to natural sciences, technology, engineering, mathematics and STEM.

STEM-Survey Results

For the question "What other disciplines do you relate natural sciences discipline to? Briefly explain how you perform this relation," responses were taken from participants both before and after they receive STEM education. The results are presented below in Figure 4.

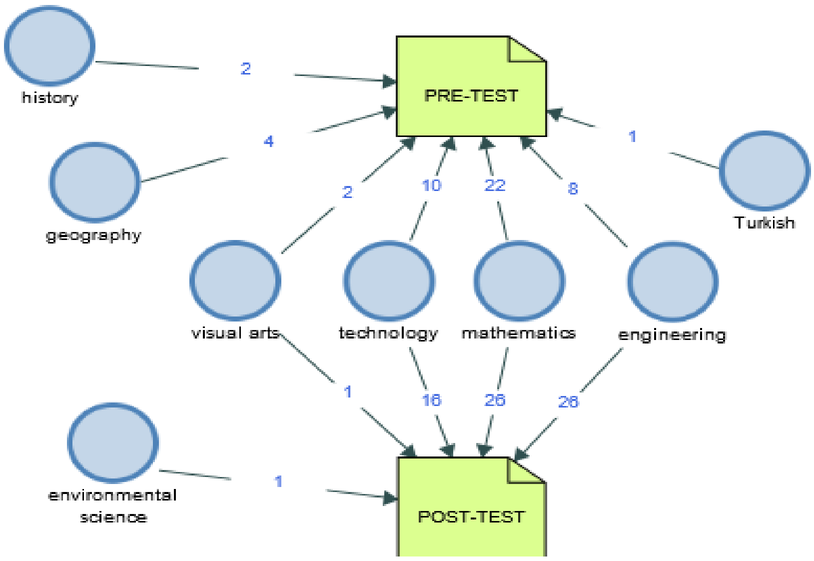


Figure 4: *The opinions of the pre-service teachers about the disciplines that were related to natural sciences*

As seen in the Figure 4, respondents listed the disciplines in a descending order of relation with natural sciences. According to the pre-test and post-test, the disciplines related to natural sciences were reported as mathematics, engineering, technology and visual arts, respectively. Apart from these, in pre-test, relation was made with geography, history and

Turkish, while attributions were also made to the environmental science in post-test with Turkish. It was seen that more relation was drawn by pre-service teachers in post-test, whereas pre-test revealed an increased diversity in disciplines compared to post-test. The obvious difference in the number of those who made relations in post-test compared to pre-test and inclusion of the difference of STEM fields may be the result of STEM education they received. The decreased diversity of disciplines and increased focus on STEM areas could be explained with the education.

In statements relating natural sciences to other disciplines, it is emphasized that the relationship between natural sciences and mathematics is at the phase of arithmetic operations and formulas: "…physics and chemistry consist of numeric data. The majority including biology to some extent has operations with numbers". The relationship between natural sciences and technology was demonstrated with technological devices such as tools made in natural sciences lesson and technological devices used during teaching of natural sciences lesson such as projector and computer. The pre-service teacher P24 stated in pre-test that: "we can take advantage of natural sciences to make technological tools or we can teach natural sciences by using technology." As for the relation with engineering, a similar relationship was found implying that engineers of the future are trained with the tools developed in natural sciences lesson: "…if the relation between natural sciences and math is in the right way and built on the solid foundation, we can bring up engineers and produce robust and useful technologies. (P3:post-test)" Its relationship with history is considered from two perspectives as the process which scientific knowledge has gone through and lives of scientists. The response given by P22 includes both perspectives: "The life of scientists, what kind of a scientific method has been implemented, and natural sciences can be better comprehended in reference to how scientific discoveries and scientific inventions were made in natural sciences." The relation of natural sciences with Turkish was stated as "the ability to transfer scientific knowledge" (P10:pre-test), while the relationship with visual arts was expressed by "much better instruction can be achieved by supporting with visuals". In addition, although it was noted that natural sciences is associated with other disciplines such as geography and environmental sciences, no statement was provided about this relationship.

In general, the relationship between natural sciences and other disciplines is understood to be dealt with at two dimensions. First, all disciplines are interrelated, and natural sciences is one of these disciplines. This was argued by P26 in pre-test indicating a chain relationship among the disciplines: "Natural Sciences, which is a discipline in relationship wih mathematics, technology, engineering and a number of other subjects, is developing hand in hand with them. This relationship continues in parallel with the interaction. For example, the development of natural sciences also affects technology, and technology affects engineering in turn. It continues as a chain ring." Secondly, natural science is a basic discipline and other disciplines help it: "When it is not enough alone, natural sciences discipline will benefit from other disciplines, mainly maths, geography and so on. (P6:pre-test)", "…technology and mathematics disciplines constitute natural sciences. (P27:pre-test)", "We, of course associate natural sciences discipline with physics, chemistry and biology. In addition to these, we may associate it with mathematics and even with all disciplines. (P5:pre-test)" The second opinion attempted to be changed in education system can be considered as a reflection of the education received by teachers during their education from kindergarden to university. Also, a very small number of participants were found to perceive and report that natural sciences as a discipline is unrelated with physics, chemistry and biology: "As a priority, of course, we associate the natural sciences discipline with physics, chemistry and biology. (P6:pre-test)"

As another question seeking support for the above-mentioned results, the participants replied the question "What do you think natural science is?" The answers provided for this question were analysed in terms of "what disciplines associate with natural sciences" in accordance with the purpose of the study. Below are given the disciplines mentioned by respondents describing natural sciences in reference with other disciplines along with respective frequencies (see in Figure 5).

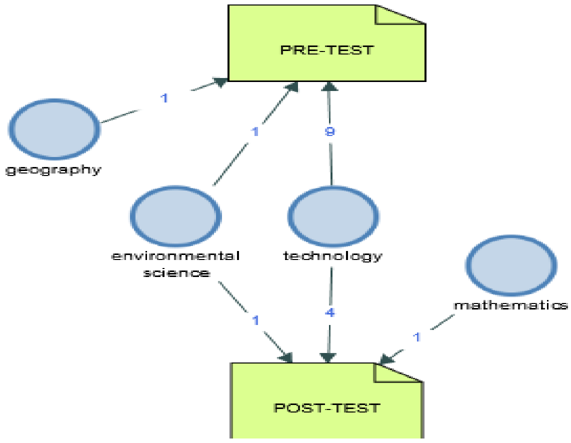


Figure 5: *The disciplines mentioned by the pre-service teachers in the definition of natural sciences*

As Figure 5 suggests, natural sciences is found to be associated relatively less with the other disciplines and mainly associated with technology in post-test. It can be inferred from the respondents' definitions that they began to perceive natural sciences as a field that facilitates observing the nature and smoothing life as a result of the STEM education: "learning and using the knowledge in everyday life (P5:post-test)", "life itself (P2:post-test)", " all natural events we observe (P4:post-test)": In the education, models of the everyday machines such as amusement parks, bridges and doors, and their working principles have been learned. In this education, natural sciences perceptions of the pre-service teachers may have been influenced in relation with making sense of life. On the other hand, it is understood from the definitions that the majority perceive physics, chemistry and biology as natural sciences branches, while a few pre-service teachers hold the misconception that these are the branches that make up natural sciences: "There are many disciplines in the natural sciences field. Natural Sciences discipline proceeds under the influence of physics, chemistry and biology disciplines (P23:pre-test).

Another question asked to participants "Would you consider to benefit from this relation for your course as a pre-service science teacher? Why?" was replied as the following.

As seen in Figure 6, almost all of the pre-service teachers stated that they intend to take advantage of the relation between natural sciences and other disciplines in the scope of their own lessons. In addition to those stating that they do not intend to do so without proposing a justification, there were also pre-service teachers who did not state their opinion or provide any answers for this question.

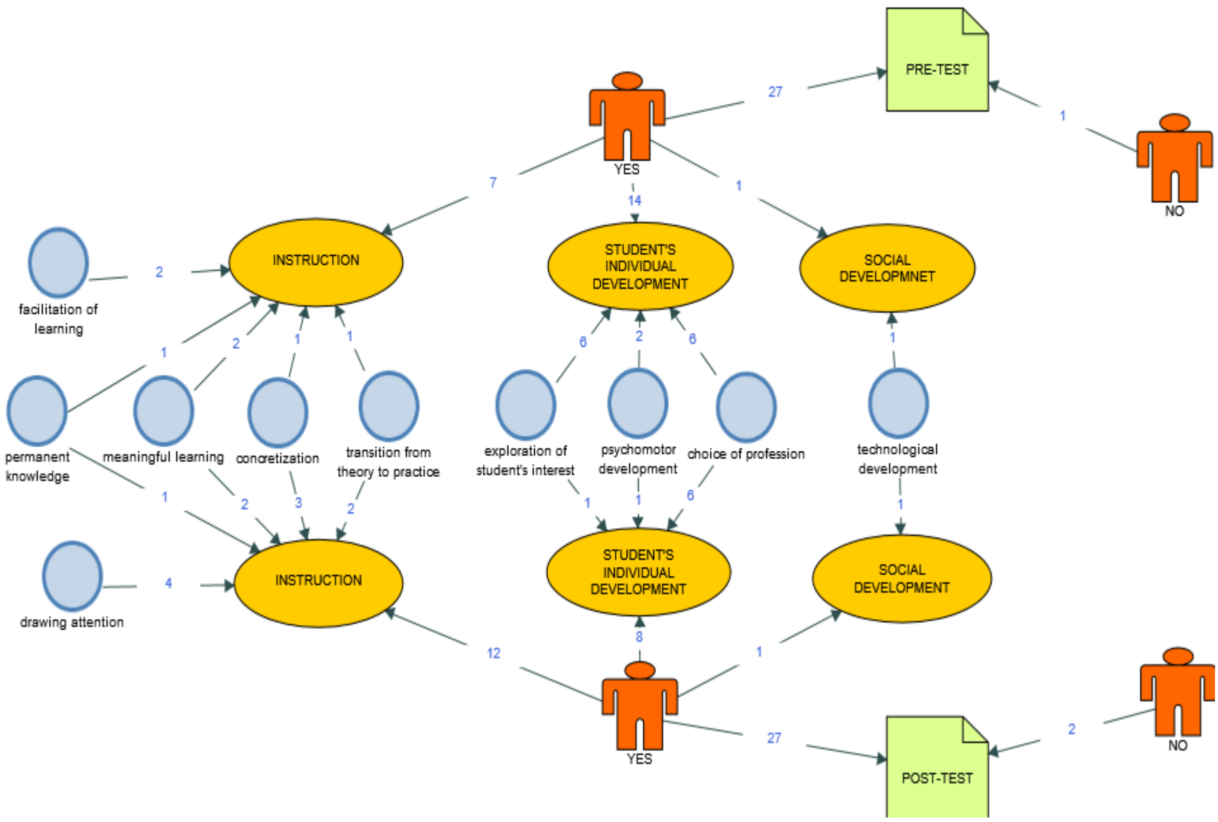


Figure 6: *The opinions of the pre-service teachers about teaching natural sciences related to the other disciplines*

The pre-service science teachers who are planning to relate natural sciences to other disciplines in their lessons believe this relation will make a contribution concerning with instruction, to individual development of students and social development. In the scope of the instructional contribution, they were seen to refer to realization of meaningful learning, concretizing of the topic, transition from theory to practice, permanent knowledge, facilitation of learning, and drawing student's attention to the lesson. Preservice teachers expressed their opinions in this regard as the following:

"…in most areas, it ensures meaningful learning by borrowing support from other fields. (P16:post-test)",

"In order to make the theoretical information transmitted to students more concrete, we take the advantage of these relationships and give examples, in this way, we make these examples concrete in the teaching area. (P6:post-test)",

"…with content knowledge, we are putting theory into practice. (P11:post-test)",

"combination of intertwined disciplines increases the efficiency. Permanent information would be gained. (P1:pre-test)",

"…if lectured together with all lessons, namely if associated with other lessons, it becomes easier for students to understand. (P26:post-test)",

"More attention could be drawn to the course by awaking curiosity about the course area by using areas such as engineering and technological development. (P20:post-test)"

The respondents indicated the contribution for students' individual development in terms of psychomotor development, exploration of their interests, and choice of profession. Preservice teachers expressed this view in the following way:

"…I benefit from the other disciplines for each student's interests. I can manage this by doing experiments and applying activities to develop hand skills. (P15:post-test)",

"… I can get them to switch to different professions. (P32:post-test)",

"When I become a teacher in the future, I will have students with different capabilities and interests in different areas. Therefore, I benefit from other disciplines for each student's interests. (P15:post-test)",

"The purpose of the course of natural sciences is to divert students to natural sciences. Experiments and observations are the first steps in a scientific research. I can think of my students as scientists and I would like to train them as individuals who do research for natural sciences and help natural sciences. For this, I would like to benefit from the relation among these four disciplines. (P32:pre-test)"

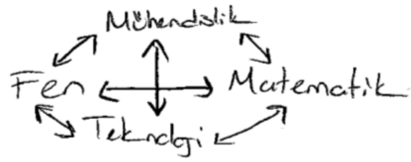
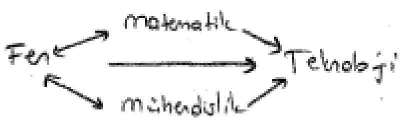
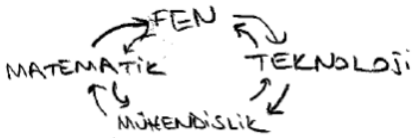
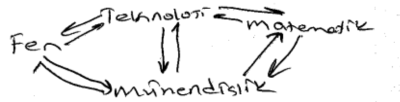
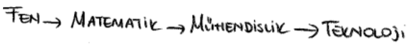
As for the contribution to the social development, the respondents stated it in relation with technological development:

"...From their relationship with each other, new inventions and various tools are obtained from the field of medicine and so on. (P31:post-test)"

"…if the relation between natural sciences and math is in the right way and built on the solid foundation, we can bring up engineers and produce robust and useful technologies (P5:pre-test).

The last but not the least, the preservice teachers' answers to the question "Draw a diagram showing the relationship among Natural Sciences, Technology, Engineering and Mathematics and explain" are summarized in Table 2.

Table 2: *The diagrams showing the relationship among Natural Sciences*

Relations	n		%		Example
	Pre-test	Post-test	Pre-test	Post-test	
All disciplines are interrelated	8	10	25	31	
Natural Sciences is related with other disciplines	6	8	19	25	 
All disciplines are circular related	1	5	3	16	
Engineering is related with other disciplines	8	2	25	6	
All disciplines are chain related	1	2	3	6	
Other	8	5	25	16	
Total	32	32	100	100	

Preservice teachers provided the following explanations in their description of the drawings: “Thanks to mathematics, which is under the influence of natural sciences, and thanks to engineering, solutions that make life easier are produced so as to develop technology.”, “They all influence each other”, “Natural Sciences is the main concept which covers all the other concepts. All constitutes a whole interrelated with each other.”

Results from Word Association Test

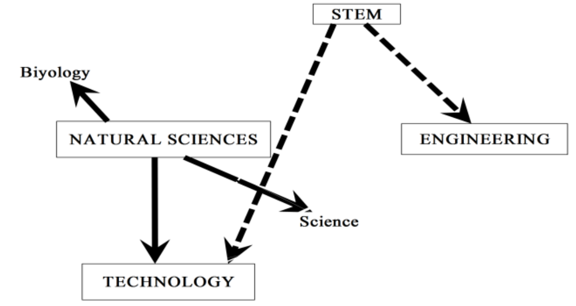
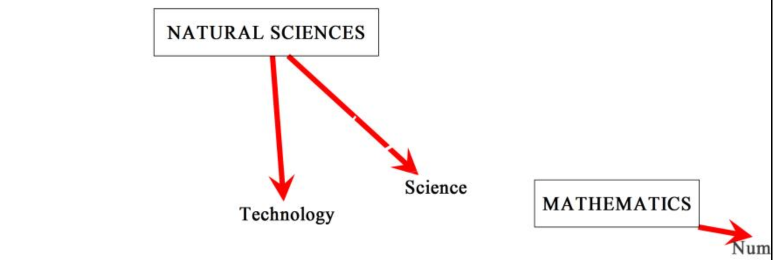
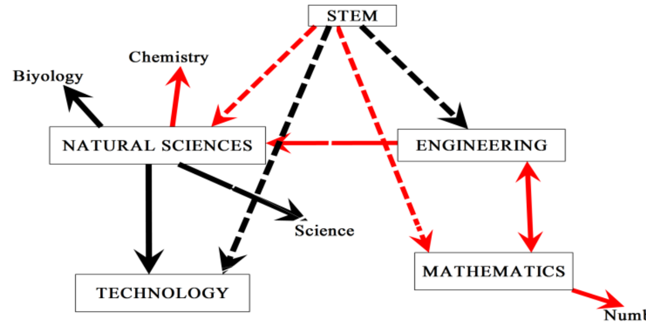
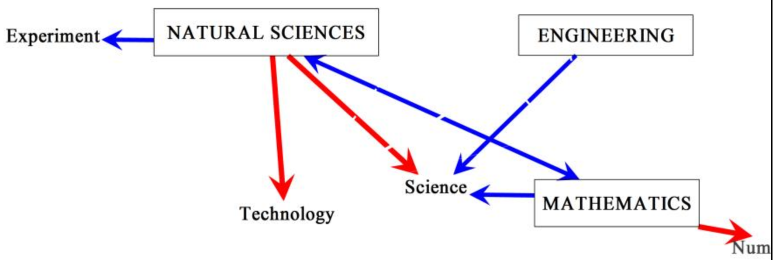
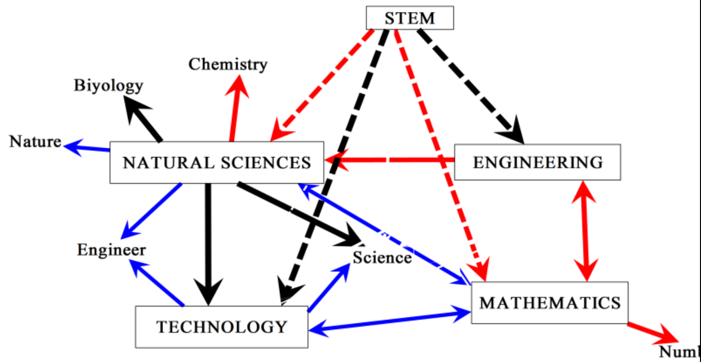
On the basis of the keywords and the related words in the STEM-WAT, the concept networks generated according to the pre-test and post-test data are presented in Figure 7. The concept networks in Figure 7 were prepared according to the cut-off technique developed by Bahar et al. (1999).

In Figure 7, the responses given by the preservice teachers are presented with the concept networks that were created using the cut-off technique. As a result;

1. For the cut-off point at and above 26, no key concept was yielded from pre-service teachers’ cognitive structures in the pre-test. However, the post-test reveals the formation of relations among Natural Sciences, Technology and STEM-related key concepts. Of these, the unidirectional relationship between STEM → Technology and STEM → Engineering as well as the bidirectional relationship between Natural Sciences↔Technology seem particularly outstanding. Remarkable outlook of relations rather than words in preservice teachers’ cognitive structure indicates that they attribute meaning to them in their memory.

2. Between the cut-off point in the range of 21 and 25 in the pre-test, Natural Sciences and Mathematics were seen to emerge as two separate concepts in pre-service teachers’ cognitive structure. Moreover, the first link was created by the relation of the concept of Natural Sciences with the term of Technology. Also, Natural Sciences and Mathematics have brought to mind the words “science” and “number”, respectively. In the post-test, although the key concepts and relationships between them started to emerge, relations rather than words continued to be on the forefront in pre-service teachers’ cognitive structure. As one examines the established relationships, it can be seen that STEM is linked with all the disciplines (STEM→Natural Sciences, STEM→Technology, STEM→Mathematic and STEM→Engineering). It is a remarkable finding that although STEM calls for all the disciplines, none of them seems to call for STEM. In terms of relations between disciplines, it is seen that unidirectional relation is established as Engineering→Natural Sciences and Engineering→Technology, while there is a bidirectional relationship as Mathematics↔Engineering. On the other hand, according to the analysis of the words associated with key concepts, it can be said that words related to natural sciences were often produced. The words are seen to be branches of Natural Sciences (physics, chemistry, biology). Hence, it can be suggested that a conceptual change occurred in pre-service teachers in a positive direction about uncovering the relationships between concepts, not the number of words produced.

3. Between the cut-off point in the range of 16 and 20 in the pre-test, a slight increase was seen in the number of words produced and the number of relations offered. Although Natural Sciences, Mathematics and Engineering seem to be perceived as science by pre-service teachers, the same attribution was not made to technology. Also, natural sciences was associated with “experiment” by the participants. Just as Mathematics recalls numbers (cut-off point at 21-25), looking at the “experiment” connotation of natural sciences, these

	PRE-TEST	POST-TEST
CP: 26-		
CP: 21-25		
CP:16 -20		

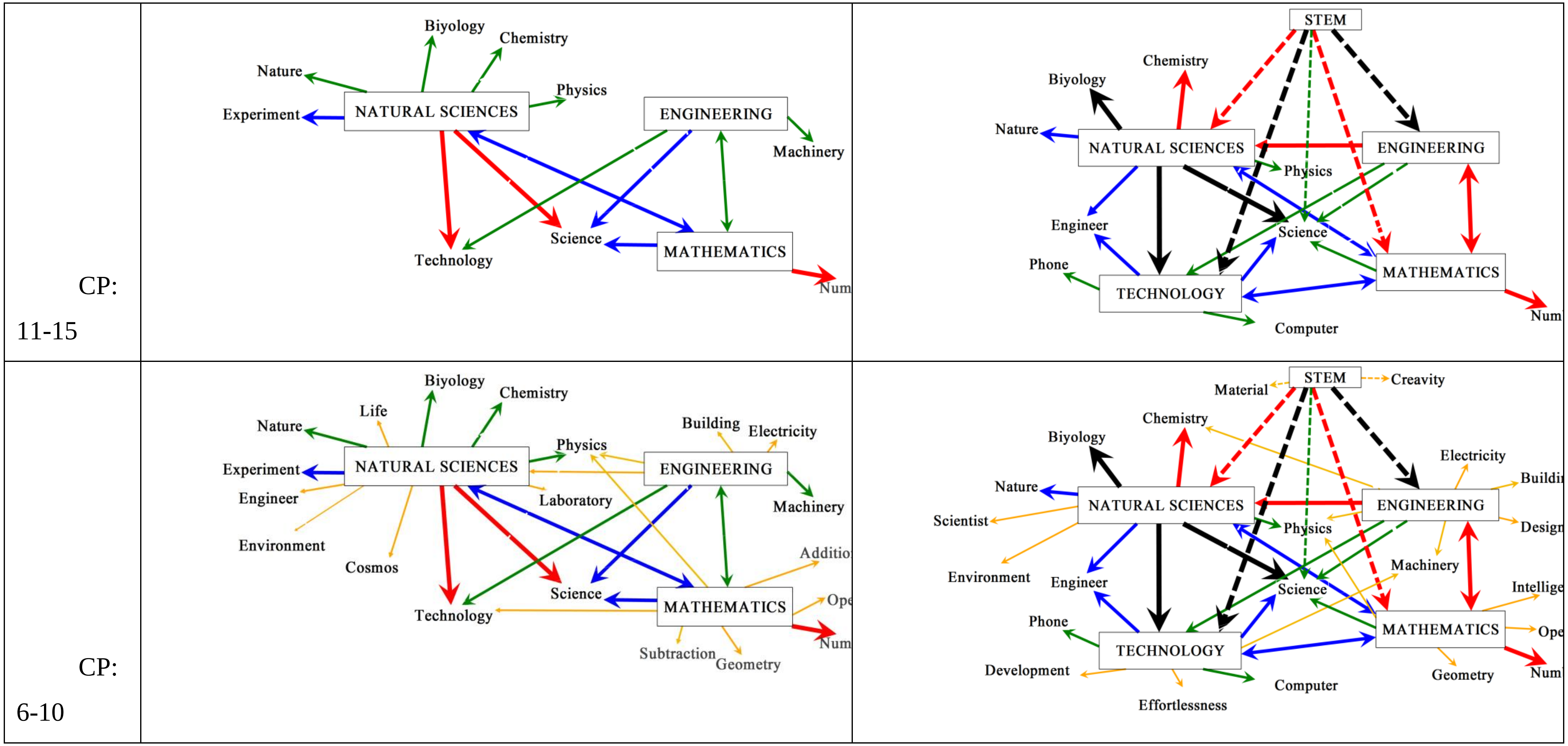


Figure 7: *The cognitive structures of pre-service teachers*

concepts (Natural Sciences and Mathematics) can be said to be identified with the words they are first associated. On the other hand, a bidirectional relationship was indicated between natural sciences and mathematics. In the post-test, all the key concepts emerged and the relationships between these concepts and the number of words associated with these concepts continued to increase. A bidirectional relationship is seen between Natural Sciences↔Mathematics and Mathematics↔Technology. At this stage, it is interesting that relations are observed between all concepts except forEngineering→Natural Sciences and Engineering→Technology. Despite the lack of the relation of natural sciences and technology with engineering (Natural Sciences→Engineering and Technology→Engineering), a link was established between the two concepts by associating Natural Sciences and Technology with the term engineering. Apart from that, when viewed relative to the number of words produced, it is understood that natural sciences recalls a greater number of words to the minds of the pre-service teachers compared to other key concepts.

4. Between the cut-off point in the range of 11 and 15 in the pre-test, a drastic increase was seen in the number of words and relationships associated with the concepts of natural sciences, but mathematics was seen in comparison to the others. In natural sciences, field-specific words began to emerge (physics, chemistry, biology, nature). Establishing relationships between key concepts continued. On one hand, a bidirectional relationship was found between Mathematics and Engineering (Mathematics↔Engineering); on the other hand, Engineering was seen to be associated with Technology (Engineering→Technology). In the post-test, the quality of the words produced seems more noteworthy than the relations made. Field-specific phrases, which had been seen in natural sciences only, began to appear in other key concepts as well. Technology was noted to call for computer and phone, while engineering called for construction. Another finding is that all of the key concepts are defined as natural sciences. Pre-service teachers seem not only to be aware of the fact that Natural Sciences, Technology, Mathematics and Engineering are branches of natural sciences, but also to perceive STEM as a type of natural sciences. However, here it can be said that the participants hold a wrong impression that STEM is a field of natural sciences.

5. Between the cut-off point in the range of 6 and 10 in the pre-test, it is seen that the key concept technology was not obvious in the network concept yet, resulting in the lack of emergence of all the key concepts. The words generated regarding key concepts seem to be field-specific. Natural sciences was linked with life, environment, universe, laboratory, and engineers; Engineering with Natural Sciences, electric, construction, and physics; lastly, Maths was linked with geometry, operation, addition and subtraction.On the contrary, it was seen that the participants did not recall technology even on the last rank. Moreover, no concept which could evoke the concept of technology was mentioned. It is strange that despite the currently experienced age of technology, the preservice teachers seem not to have enough connotations in mind about technology. In addition, the finding that they do not regard technology as natural science seems to support the inference above. Investigation of the established links lastly reveals unidirectional relationships as Engineering→Natural Sciences and Mathematics→Technology. Also, the concept of engineering was determined to be associated with physics, and there was an established link between Engineering and Natural Sciences. In general, very little connection can be mentioned between the associated words and the key concepts. As the links are examined, outward networks are seen. In other words, it may be said that the preservice teachers just think the words associated with key concepts with keywords are unique to that area, being unaware that the same words could be related with different areas. In the post test, five key concepts were seen with more complicated and intertwinted relationships. In addition, a larger number of links were seen to be established between the associated words and the key concepts. Those links were found to

reveal an inward structure. In this case, it could be argued that the students noticed the possibility to associate the concepts associated with a specific field with other areas as well. Besides, the relationship between the key concepts is seen to be expanded further. For instance, by expressing that Natural science, Mathematics and Engineering concepts are related with physics, another connection was found among these three fields. Similar relationships were noted with chemistry in the context of Natural Sciences and Engineering, and with machinery in the context of Technology and Engineering. As regards to the key concepts, the number of words associated with specific areas continued to increase. (Uses such as Mathematics-operation, geometry, intelligence; Natural Sciences-scientist, environment; Engineering, electric, design; Technology-development, convenience were seen).

Overall assessment of the Word Association tests results demonstrates that the relationship among the concepts of Natural Sciences, Technology, and Mathematics was branched and independent in the pre-test. Despite the higher number of concepts in the pre-test compared to the post-test, limited relationship was reported between them by respondents.Contrarily, post-test results show a decrease in the number of concepts, while the relations increased significantly. In addition, the concept STEM is seen to be linked with Natural Sciences, Technology, Engineering and Maths in the post test. The relationship among the key concepts of Natural Sciences, Technology, Engineering and Mathematics implies that initially the participants' cognitive structure was partially independent before the implementation. After the implementation, the pre-service teachers could draw links between the concepts revealing the interrelation among them.

The pre-service teachers' responses to the WAT, which were discussed in detail in the concept netword above, are summarized in the following Table III.

Table 3: *The frequency of the pre-service teachers' responses to the Word Association Test*

Key Concepts	Frequency of the responses	
	Pre-Test	**Post-test**
Natural Sciences	86	83
Technology	115	94
Engineering	103	95
Mathematics	88	80
Total	392	352
STEM	-	101

As seen from the Table III, in this study, the total number of words in the WAT was noted as 392 before the course, but 352 after the course. Also, in both pre-test and post-test maximum words were noted for Technology and Engineering, whereas the concepts of Natural Sciences and Mathematics covered the least words. Besides, the number of words specified in pre and post-test was approximately equal in Natural Sciences and Mathematics; a higher number of words was found to be allocated for Mathematics and Engineering during pre-test than in post-test.

Given the different number of words produced in the table, it is understood that the total number of keywords decreased in comparison of post-test (352) to pre-test (392). Beside, the decrease was seen in the number of words associated with each of the keywords after the STEM education. Frequency tables and the concept networks built on them reveal that quality and significance of the given words increased as a result of the education, and the reduction in the level of students' knowledge can be said to be more than the decline in the number of words produced actually.

CONCLUSION and RECOMMENDATIONS

In both Turkey and other world countries, studies on interdisciplinary approaches can be found in academic curricula of many disciplines under the heading of "associating with other courses". However, most researches suggest that teachers lack experience in research on the relationships and connections between the disciplines of a particular curriculum (Jacobs, 1989; Mason, 1996; Aybek, 2001; Karacaoglu, 2008; Bümen, 2005). In order to produce a solution to this problem caused by interaction of disciplines, a number of education approaches were introduced, one of which is the STEM approach that integrates the disciplines of natural sciences, technology, engineering and mathematics. STEM is a learning approach by which basically student-centered and collaborative learning is emphasized and the four disciplines are taught simultaneously in real-life situations rather than teaching of them separately and in different areas (Herschbach, 2011; Israel, Maynard and Williamson, 2013, Hom, 2014).

Before the STEM education, the pre-service science teachers could also associate science subject with various courses; but it could be said only a few of them do so. It is understood that these relations mostly include Biology, Physics, Chemistry, Earth, Sky and Environmental Sciences, Health and Natural Disasters, which are referred to as basic knowledge about natural sciences in the science curriculum (MEB, 2013). After receiving the STEM education, a marked increase was recorded in the number of relations with other courses in spite of the reduction in the number of associated disciplines. This growth includes the STEM fields. The decrease in discipline diversity against increased focus on STEM fields may be a result of the interdisciplinary STEM education they received in this study. The pre-service teachers pointed out that natural sciences subject could be associated with Turkish, history, visual arts, geography and environmental science besides STEM fields.

When we look at their projections on interdisciplinary science teaching in their future classes, the reflection of this relationship could be felt. The pre-service teachers just noted mathematics to associate with science teaching in the future prior to the STEM education. Other interdisciplinary studies particularly report relation between natural sciences and maths disciplines (Czerniak et al., 1999; Pang and Good, 2000). This might have been resulted from the frequent application of mathematics to natural sciences and the relation between mathematics and real life often observed in natural sciences. Dugger (2010) thinks that in this trend, as he called "STEM", technology and engineering are both pushed into the background. This approach, which places very little emphasis on technology and engineering, seems very unlikely to help individuals establish a proper relationship among STEM disciplines (Bybee, 2010). Contrary to these results, the pre-service science teachers in this study could associate Natural sciences with Mathematics, Technology and Engineering after they were given interdisciplinary education as a combination of mathematics, engineering and technology in the context of science class (See Figure 8). These relations were in Mathematics as "making arithmetic operations and using formula in natural sciences course", in Technology as "the tools made in natural sciences course and technological devices used in science classes such as projector and computer", and in Engineering as "developing instruments in natural sciences course". This result can be explained with the fact that integration of STEM disciplines was realized in the framework of engineering design problems during the pre-service course (Roth, 2001; Wendell, 2008; Daugherty, 2012; Strong, 2013). Since Engineering Design Process (EDP), as the production process of technology, requires to use basic engineering knowledge and skills as well as natural sciences and mathematics principles, it naturally ensures relationships of STEM disciplines with each other.

From overall assessment of relations between natural sciences and other disciplines drawn by pre-service teachers, it is seen that they address such relation from two aspects: "All disciplines are interrelated and natural sciences is one of these disciplines" and "Natural

Sciences is the basic discipline, and other disciplines help it" (see p.11). The diagrams made by pre-service teachers to show the relationships among the four disciplines support this result. The first aspect was supported by drawings implying that all disciplines are related, disciplines are cyclical and there is a chain-like relation among them. The other aspect (Natural Sciences is the basic discipline, and other disciplines help it) was supported by drawings suggesting that Natural Sciences is associated with other disciplines. This result seems consistent with the multidisciplinary relation approach in STEM education. In STEM, teaching is performed by harmonization of the contents of four abovementioned disciplines or placing one of them in the focus to teach its content by means of the other three disciplines (Moore et al., 2013). However, the second aspect reveals that the axis course approach remains unchanged, even though the changes made to the curriculum (MEB, 2013) were intended to change this understanding.

Another conclusion of the present study suggests that almost all pre-service teachers think of benefiting from relation of natural sciences with other disciplines in their classes; but they seem to be hindered in practice. This result shows similarities with the study by Aladag and Sahinkaya (2013). No concrete change has been reported following the STEM courses, possibly because the interdisciplinary STEM courses mostly offer activities to elicit the relationship among the four disciplines. Other studies also indicate the need for pedagogical content knowledge as well as sufficient subject area knowledge to be able to have interdisciplinary skills (Aybek, 2001; Frykholm and Glasson, 2005). It is known from many studies that science teachers graduate without having adequate pedagogical content knowledge (Aydın and Boz, 2012). Other probable reasons for this situation are reported in the literature. For example, pre-service teachers are taught lessons which provide really a few relations with other disciplines throughout their secondary education. Alternatively, little emphasis can be placed on interdisciplinary relation to improve both pedagogical content knowledge and subject area knowledge in the courses they have taken during undergraduate education. Also, it is noted that despite the updating of the curricula, integrity of the disciplines is not highlighted remarkably at the required extent in courses within the existing education system; rather, disunited teaching of the contents is sustained.

On the other hand, the pre-service teachers who are thinking of associating natural sciences with other disciplines in their future classes, hold the belief that such relation would be useful for both individual and social development of students. In terms of teaching benefits; the participants mentioned realization of meaningful learning, concretizing of the topic, transition from theory to practice, permanent knowledge, facilitation of learning, and drawing student's attention to the lesson. The respondents exemplified the contribution to students' individual development and psychomotor development, exploration of their interests, and choice of profession. In this regard, STEM course could have made contribution to pre-service teachers' developing positive attitude towards interdisciplinary STEM approach. In a similar study on pre-service teachers associating social studies with mathematics lessons, it is reported that the relation is significant as it helps to internalize the concepts, addresses topics at different dimensions, increases the effectiveness of learning, ensures permanent learning, increases the interest in the course, provides meaningful learning, brings a different perspective to happenings, draws cause-and-effect relationship, notices the relationship between the contents of different courses, and associates the knowledge with real life (Aladag and Sahinkaya, 2013). The results of this study are in parallel with the present study.

As seen above, while the pre-service teachers expected contribution from interdisciplinary relation to individual development prior to the education, they thought that it would contribute to their teaching skills as a result of the education. The most important reason could be their awareness of the change in their instructional knowledge as a result of the education they received. Whereas the justifications indicated by prospective teachers were somehow superficial before the education on interdisciplinary relation, they gained a little more depth. Mansur (2009) argued that although the teachers have a positive attitude towards a new approach, they might have a negative attitude towards the applicability of this approach in the classroom. It might be because they lack concrete experience although they have an idea about this approach. Here the need becomes apparent to support relational comprehension of pre-service teachers for their professional development relating to their own discipline as well as other disciplines to be associated. It seems essential that interdisciplinary relationships be referred in teacher education programs and in-class activities.

For the purpose of equipping teachers, as practitioners of interdisciplinary curriculum, with knowledge and skills, teacher education programs offered in education faculties must include courses supporting integrated teaching knowledge, classroom applications and activities. To this end, it is recommended to collaborate with faculties of engineering and science and arts so that teacher education can be both diversified and enriched. Furthermore, pre-service teachers should be given the opportunity to take courses from faculties of science and arts, engineering and technology as well as faculty of education and therefore they should be encouraged to have a rich life experience (Corlu, 2012; Corlu, 2013).

Other recommendations would include providing adequate education for pre-service teachers at undergraduate level. Finally, works and studies could be included in “School Experience” and “Teaching Practice” courses in order to eliminate handicaps faced in practice.

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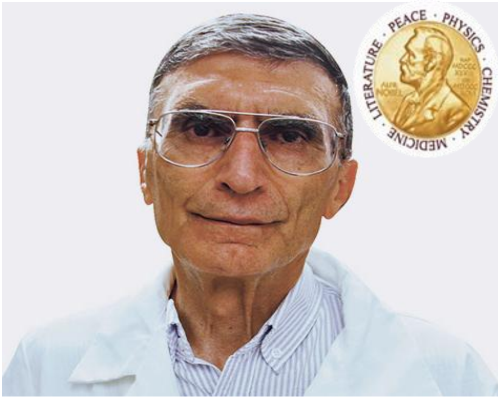
APPENDIX-1

A sample of worksheets

BRIDGE



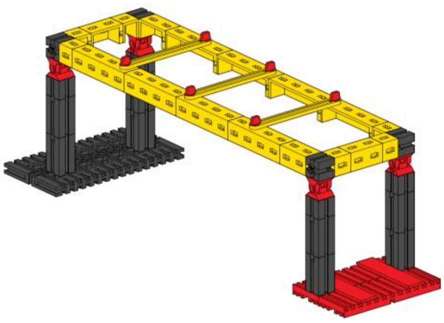
Turkish scientist Aziz Sancar, with his "DNA repair study", making a decisive contribution on medical world, receives Nobel Prize, dedicated this award to Anıtkabir. At the same time, he wants to pay off his fidelity to his hometown, where he grew up in Savur, Mardin. For this purpose, by giving a great contribution on fixing and enhancements of the country roads, he is planning to build a bridge to relaxing traffic. So, he needs some help from the experts and he contacts with an expert team in the field of Physic, Maths, Engineering and Technology. You undertook this essential task.

A bridge has four characteristic specialities,

- Being safe
- Being long
- Being cheap
- Being aesthetic

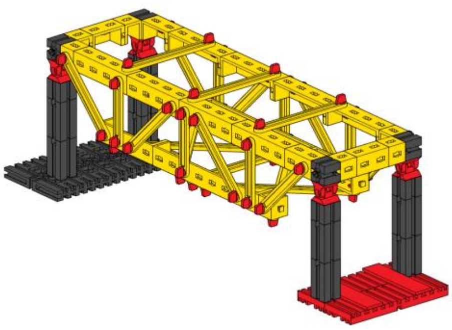
Before starting on building the bridge, you have drawn three different plans of the bridge. By doing prototypes of this drawings,make a decision on the theme of the characteristic property of it.

PROTOTYPE 1:



- Do same experiment with placing different weigths on the bridge.
- What can you say about the stability of it? Draw and name the static parts of the bridge.

PROTOTYPE 2 :



- Do same experiment with placing different weigths on the bridge.
- What can you say about the stability of it? Draw and name the static parts of the bridge.

PROTOTYPE 2:

- Do same experiment with placing different weigths on the bridge.
- What can you say about the stability of it? Draw and name the static parts of the bridge.

- In which areas and what aims can this bridge be used? Give answers with justifications.
- At the end of your assesment, according to these criterias, which model did you choose? Why?