Cognitive Structures of Elementary School Students: What is Science?

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Abstract
The aim of this study is to examine the change in the cognitive structures of elementary school students in respect to the concept of science through word association test in a constructivist approach based project. The study was conducted with 50 students attending to 6th and 7th grades. Students were applied a 90-minute activity in scope of the training on science, scientist and scientific knowledge under the project that lasted for 5 days. A word association test that included the concepts of science, scientific knowledge, scientific method, scientist, research, project, experiment and laboratory was applied at the beginning (pre-test) and at the end (post-test) of the project. A frequency table, which consists of concepts of word association test and response words, were prepared in data analysis. According to the obtained frequency table, concept networks that revealed the cognitive structures of students were drawn. Upon reviewing the frequency table of the pre-test and post-test of students, and the concept networks, it was observed that the cognitive structures in the relevant concepts of students changed positively. Accordingly, it was concluded that word association tests prove an effective method for revealing the cognitive structures of students. Study findings were discussed in comparison with the studies in the literature, and recommendations were given.
Keywords: Word association test, cognitive structure, elementary school students.

Introduction

The vision of Turkish science curriculum has been defined as "Educating all students as scientifically literate individuals" (Ministry of National Education [MNE], 2013). Scientifically literate individuals have the skills of scientific process for the basic knowledge of science. As it has been included in the objectives of science curriculum, it is very important to comprehend how scientists construct scientific knowledge, that this knowledge is produced as a result of the mutual effort of science and scientists, and lastly, the significance of scientific studies. The importance of educating the students of today as individuals who can make effective decisions, solve problems, have self-confidence, are open to collaboration, can communicate effectively is emphasized (MNE, 2013). Accordingly, students who receive education are expected to have very high success rates.

However, it was determined in several studies that students have a low success rate in science (Bağcı Kılıç, 2003; Education Research and Development Association [ERDA], 2003; Kelly, 2002; Uzun, Bütüner, & Yiğit, 2010). In order to resolve this problem, alternative teaching approaches that help students with learning are bringing into focus. Based on this approaches several countries renew their curricula based on constructivist approach (American Association for the Advancement of Science [AAAS], 1989; MNE, 2013; National Science Teachers Association [NSTA], 2003;National Research Council [NRC], 1996).

Constructivist approach suggests that individuals construct knowledge in their minds by associating it with preliminary knowledge and previous experience in their minds (Bodner, 1986; Tobin, 1993). Concepts constitute a basis for learning other associated concepts and advanced level science concepts (Dykstra, 1986). In other words, if the preliminary knowledge of students is not compatible with the new knowledge, new knowledge is not constructed. However, if existing knowledge and new knowledge are compatible, concept is learned in a more easily manner (Posner, Strike, Hewson, & Gertzog, 1982). While learning science, students interpret new knowledge with their existing ideas and beliefs, and accordingly new knowledge is replaced or reconstructed as well (Palmer, 1999).

According to constructivist approach, which is the general philosophy of curricula, it is very important to know how students give meaning to knowledge and associate concepts in their minds; that is, to know their cognitive structure. Therefore, different strategies should be used for students' comprehension and perception of concepts. One of the techniques that reveal the cognitive structure of students and the relation between the concepts in this structure is word association test (WAT) (Bahar, Johnstone, & Sutcliffe, 1999; Hovardas, & Korfiatis, 2006; Shavelson, 1974). According to Preece, (1977), the effect of this technique on learning science is based on Johnson's (1965, 1967) researches. In WAT, highly relevant basic concepts are selected and students are asked to write down the words constructed by those concepts in the order within certain duration of time. Students write the concepts under each other within the given time. Each key concept is given in another page so as to prevent interaction between key concepts. As a result of WAT, it can be determined whether the concept has been understood by analyzing the quality and quantity of the words assigned by students for each key concept. In other words, the higher the number of words given as a response to the key concepts, the better the comprehension is performed. However, the response to a key concept should be relevant to the concept itself (Bahar et al, 2014; Basol, 2013). Therefore, it has been aimed to reveal the cognitive structure of elementary school students, who are targeted to become scientifically literate, in respect to the concept of science and other seven concepts that are assumed to be relevant (scientific knowledge, scientific method, scientist, research, project, experiment and laboratory) through the WAT.

Method

Research Design

Survey, which is a qualitative research method, has been employed in this research. Survey is a research design that aims for describing a status (Frankel & Wallen, 2000). In this study, survey design was used because the cognitive structures of elementary students in terms of science, scientific knowledge, scientific method, scientist, research, project, experiment and laboratory was described and examined.

Participants

The study group consisted of 50 students attending to 6th and 7th grades who participated in a project supported by The Scientific and Technologic Research Council of Turkey (TUBITAK) in 2014–2015 academic year. The students consisted of 25 female and 25 male students.

Instrument

Word association test (WAT) was used in the study as a data collection tool. The key concepts that constitute WAT are science, scientific knowledge, scientific method, scientist, research, project, experiment and laboratory. These key concepts are believed to be relevant to the activity of the TUBITAK Project entitled as "Entertaining Science: What is Science?" "What is the Scientist Image of Students?" and "What Are Characteristics of Scientific Knowledge?" and they were obtained as a result of the relevant literature review (Unal Coban, & Ergin, 2008; Dogan Bora, Arslan, & Cakıroğlu, 2006; Tasdere, Ozsevgeç, & Turkmen, 2014). The key concepts excluding scientific method are included in the 6th and 7th grade science curricula. Furthermore, the opinions of two science education experts and two science teachers were considered during the selection of these concepts.

Procedure

Word association test (WAT) was applied as the pre-test on the first day of the 5-day project, and as the post-test at the end. Before the post-test, students were applied the activity entitled as "Entertaining Science: What is Science?" "What is the Scientist Image of Students?" and "What Are Characteristics of Scientific knowledge?" This activity lasted for 180 minutes. The characteristics of science and scientist were mentioned in the first 90 minutes. In the second part, participants were enabled to gain knowledge on the characteristics of scientific knowledge through news, texts and images received from different resources (newspaper and book), and the emphasis was laid on characteristics of scientific knowledge.

In the WAT, the students were asked to write 10 response concepts for each key concept. Before the test, students were given explanation about WAT and then 60 seconds were allocated for each concept. Even though different durations are defined in the literature (Bahar et al., 1999; Hovardas, & Korfiatis, 2006; Nakipoglu, 2008; Shavelson, 1974), it was believed that a longer duration should be given for elementary school students. Students wrote down the words that they thought to be associated with the key concept during this given time. After the given time was up for each concept, it was moved over to the next key concept so that the students could allocate equal time to each concept in the test.

Data Analysis

The level of comprehension for a given key concept depends on other words associated with that concept. It is thought that a concept that is not associated with any words is meaningless and the meaning is enhanced as the word is associated (Bahar et al., 2014). The data obtained from WAT were analyzed using the number of words and semantic association technique (Atasoy, 2004). The number of words generated by students for each key concept was determined at the end of WAT, and frequency tables were prepared for these words. Response words that were observed to be irrelevant to key concept were excluded from the evaluation.

The frequency tables were prepared separately for pre-test and post-test. These frequency tables were taken as a basis for developing concept networks. Cut-off point technique was used

for developing the concept network. In this technique, 3-5 less than the maximum number of response words assigned for any key concept in a word association test is used as the cut-off point (Bahar et al., 1999). The responses found to be above this response frequency were written in the first section of concept network. Then, the cut-off point was periodically reduced down to develop the concept network (Bahar et al., 1999). In the study, the reliability was ensured by receiving the opinion of a science education expert in order to confirm whether the data obtained from frequency tables were represented in the concept networks devised accordingly (Miles & Huberman, 1994).

Findings

As a result of WAT, a frequency table indicating the number of response words produced in pre-test and post-test for each key concept was developed (Table 1).

Table 1.*Total number of different response words to each key word in pre and post WAT*

	Total number of different responses	
Key words	Pre-test	Post-test
Science	228	291
Scientist	198	297
Scientific knowledge	175	266
Scientific method	139	270
Research	180	319
Project	134	230
Experiment	191	346
Laboratory	178	345
Total	1412	2364

As seen in Table 1, it is observed that the total number of words assigned by the students in pre-test in relation to key concepts was 1412 and it increased to 2364 in the post-test. Furthermore, it is seen that the number of response words produced for each key concept separately increased in the post-test as compared to pre-test.

As a result of WAT, the frequency tables, which indicate the numbers of response words produced for each key concept, were constructed. WAT completed by each student were examined one by one and response words were encoded in the table with their numbers while developing the frequency tables. Accordingly, the frequency tables consisting of key concepts and produced response words for pre-test (table 2) and post-test (table 3) were given

Table 2. *The Frequency Table consisting of key concepts and produced response words (pre-test)*

	Key concepts							
Response words	Science	Scientist	Scientific knowledge	Scientific method	Research	Project	Experiment	Laboratory
Science		7	11	20	14	10	10	20
Scientist	14		3	8	7	2	8	16
Scientific knowledge	22	10	7	10	18	6	4	6
Research	20	16	20	17	6	25	16	16
Experiment	21	15	10		20	12		
Laboratory	12	6	1	2	5	1	34	1
Inventor	10	17			1	8	3	3
Invention	20	20	10	5	8	7	9	7
Technology	8		5	3			1	
Provable	1		14	2				
Physics	6	2	2	2			3	3
Chemistry	9	1	3				10	8
Biology	6	1	3	3			5	6
Astronomy	1		1	2				
Mathematics	2							
Einstein	7	21	1	2			1	1
Thomas Edison	3	7					2	1
Newton	3	6	1					
Discover	3	3	3		11		4	3
Fiction	2							
Inquiry	1	4	4		5		3	3
Observation	3	6		4	3	2	3	6
Curious	10	11	6	2	15		4	1
Data			3					
Brain			4	2				
İnternet			6		30	2		
Different way	4		1	14				
Formula				4				
Process				2				
Solution				17			1	1
Reference				5				
Problem				3				
Instructive				4				
Real			3					
Certain			10	3				
Intelligence	17	29	4	4	2	2	2	3
Laboratory tube	3		1	1			13	19
Logical	6	4	6	4	1	1		
My creation						6		
Beaker							15	11
Laboratory coat							6	6
Chemicals							11	5
Material						3	10	11
Microscope	1						3	13
Electroscope							3	3
Try							6	

Learn			7		1	3	2			1		
Teacher			3									
Homework							18					
School							6	1		3		
Subject							10					
Solution						4	7					
Hypothesis			1		1	7						
Education			1									
Life	12		4									
TUBITAK	1						6			1		
Plan		2										
Think		3				7						
Discussed			2									
Extensive			2									
Encyclopedia			3			13						
Theory			2		2							
Experience			3									

As seen in Table 2, it was determined that students associated several different words with the key concepts given in WAT. Students associated the "*invention"* with all of the key concepts. In other words, "*invention"* has been determined as the mutual recurrent word. It was observed *inventor, observation, inquiry, curiosity and intelligence* were commonly used as well. On the other hand, the words written by students for only once in response to any given key concept were not included in the frequency table. Excluded words are "*education*" for scientific knowledge, and "*light, universe, time, civilization, atom, electricity, law, iodine, nitric acid*" for science. Furthermore, it was determined in the pre-test frequency table that students repeated similar concepts without associating with each other. Therefore, concepts that are synonyms or have similar meanings were combined under a mutual concept name in the pre-test frequency table.

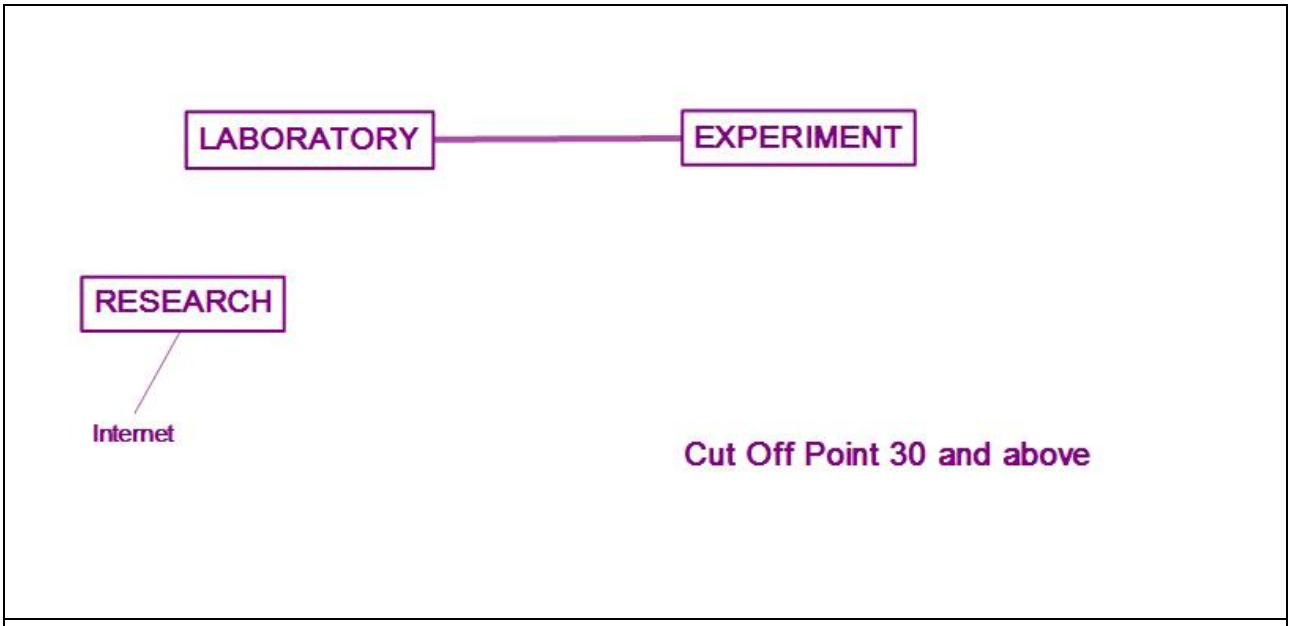
Table 3. *The frequency table consisting of key concepts and produced response words (post-test)*

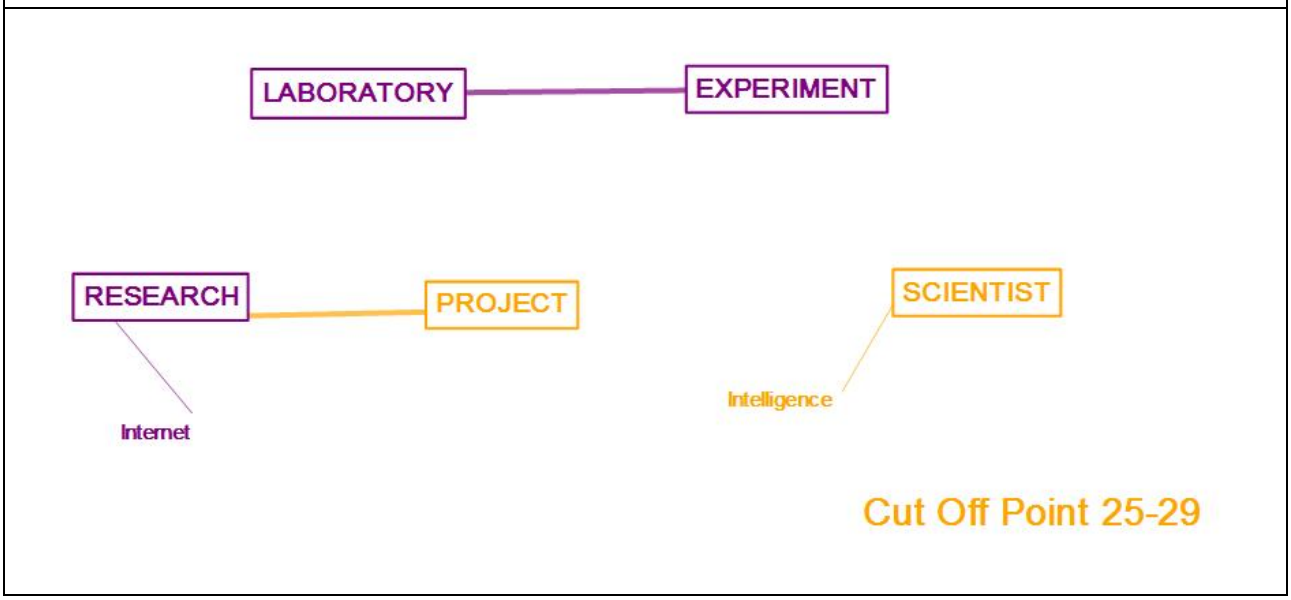
	Key concepts							
Response words	Science	Scientist	Scientific knowledge	Scientific method	Research	Project	Experiment	Laboratory
Science		13	28	20	19	19	14	13
Scientist	30		16	12	14	8	18	19
Scientist (man)		10		1				
Scientist (woman)		13		1				
Scientific Knowledge	23	8		21	17	6	11	7
Research	35	29	26	23	2	31	23	15
Project			2	4	12		3	4
Experiment	26	22	23	27	24	22		35
Laboratory	11	10	8	9	6	3	29	
Scientific Method	7		10	9	7	1	6	4
Inventor	5	5	8	2	1	3	5	3
Invention	9	8	9	2	3	10	12	5
Technology	7	3	3	2	1	1	1	1
Provable			11				2	1
Physics	7	4	9	6	2	6	21	24
Chemistry	7	4	9	6	2	6	21	24
Biology	7	4	9	6	2	6	21	24
Einstein	2	13			2			
Thomas Edison		5						
Newton		11			1			
Eureka		4			1	1		
Arşimet		8						
Galileo		4						
Benjamin Franklin		3						
Marie Curie		6		1		1		
Discover	7	13	3	5	8	4	7	2
Fiction								
Inquiry	4	12	7	7	8	4	4	1
Observation	7	11	13	15	18	13	12	10
Curiosity	21	19	10	2	16	5	8	5
Data				2	2	2		
Brain	1		1					
Internet	1		2	1	20	2		
Different way								
Foresighted		3						
Solution				7	2	2		
Inscructive				8	1	1		
Certain			2					
Uncertain			22					
Creative view	2	4		4	4	4		
Wisdom	3	5		3				
İntelligence		13		4				
Lab tube				6	1		18	16
Logical	2	2	2	5				
Beaker	3			1	2	1	21	27

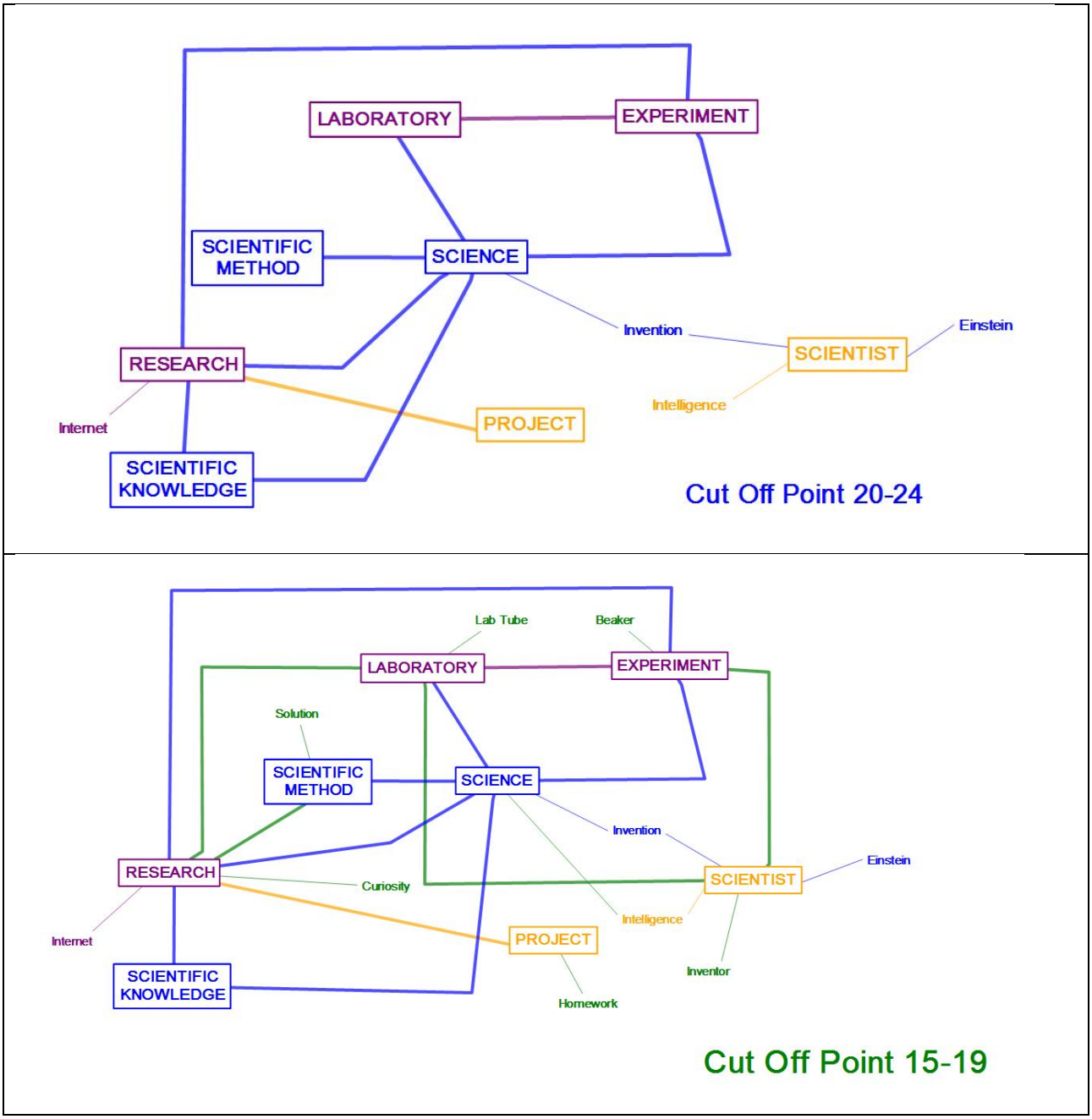
Lab coat		6			2		3	2
Chemicals							5	6
Material							6	1
Lamina							4	10
Lamella							4	9
Lens							1	2
Spirit lamp							2	5
Graduated cylinder								6
Dropper							4	2
Watch glass							4	
Glass rod							4	7
Erlenmeyer				2		1	19	22
Nitric acid								
Microscope	4			2	1		8	17
Learn	6		11		10	1	2	4
Homework					12	28		
School	2				1	4	1	2
Subject								
Reason					4	4	4	2
Space								
Hypotesis	3		2	5	19	8		
Determination	3	8						
Patience	3	8						
Design	3			1		2		
Question					5	1		
Life	4	1	4	1				
Effort	4							
Future	4							
Art	7							
TUBITAK	2							
Think	19	1	9	8	6	1	6	2
Encyclopedia			1		16			
Theory			1					
Literature review				3	5	2		
Report			4	1	4	2		
Teamwork				18	1	3		
Computer					10			
Performance					1	4		
Book			1		17	3		
Library					4			
Human		4		4	4	4		
Entertaining							3	3
Reaction							4	1
Explosion							4	2

As seen in Table 3, it was determined that there was a considerable increase in the number of produced words in post-test. The curiosity and observation were associated as the mutual response word to all key concepts in the post-test.

The concept networks which indicate the connection between the key concepts and the response concepts associated with these based on Table 2 and Table 3 frequency tables are given in Figure 1 and Figure 2.


LABORATORY
EXPERIMENT
RESEARCH
Internet
Cut Off Point 30 and above


LABORATORY
EXPERIMENT
RESEARCH
PROJECT
SCIENTIST
Intelligence
Internet
Cut Off Point 25-29


LABORATORY
EXPERIMENT
SCIENTIFIC METHOD
SCIENCE
Invention
SCIENTIST
Einstein
RESEARCH
Intelligence
Internet
PROJECT
SCIENTIFIC KNOWLEDGE
Cut Off Point 20-24
Lab Tube
Beaker
LABORATORY
EXPERIMENT
Solution
SCIENTIFIC METHOD
SCIENCE
Invention
RESEARCH
Einstein
SCIENTIST
Curiosity
Intelligence
Internet
PROJECT
Inventor
SCIENTIFIC KNOWLEDGE
Homework
Cut Off Point 15-19

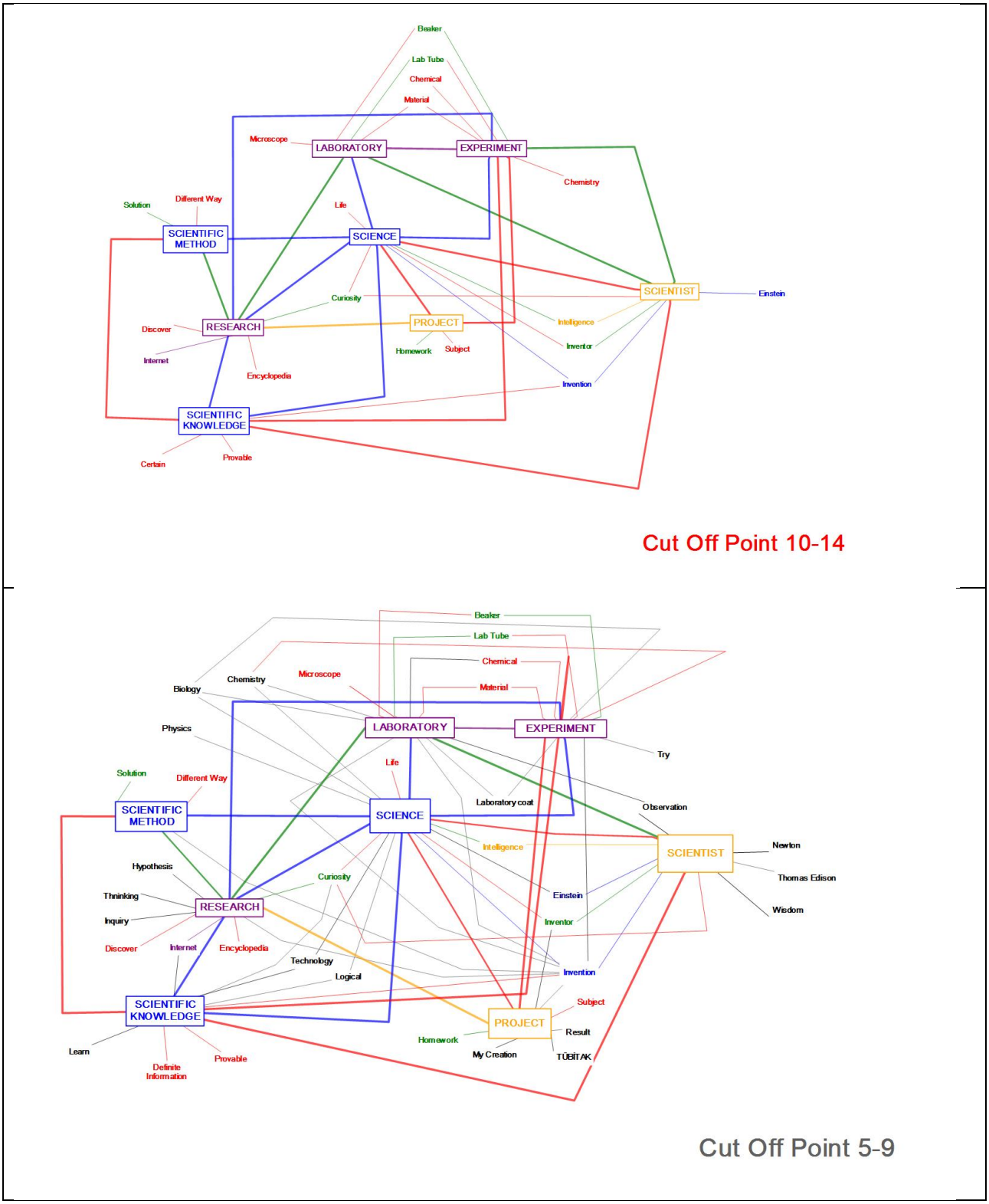


Figure 1. *Concept networks developed based on pre-test key concepts*

Figure 1 can be interpreted as follows:

Cut-off point 30 and above: Laboratory, experiment and research concepts that are frequently used in everyday life have emerged within this range. It was determined that students associate the experiment and laboratory. Furthermore, it was observed that 30 students associated the "*research"* with the "*internet"*.

Cut-off point 25 - 29: Project and scientist concepts emerged within this range. It was determined that students associate the *"project"* and *"research"*. "*Scientist"* was associated with the "*intelligence"* within this range.

Cut-off point 20 - 24: All key concepts emerged within this range. An association between science and all key concepts, except for the key concepts of "*scientist"* and *"project",* was performed. Furthermore, an association was made between the concepts of experiment and research; and research and scientific knowledge. Concepts of scientist was not associated with other key concepts. "*Scientist*" was seen to be disconnected from other concepts in the concept network. Nonetheless, "*scientist"* was associated with the responses "*Einstein"* and "*invention"*. Furthermore, the "*invention"* was the mutual response that was associated with "*science"* and "*scientist"*.

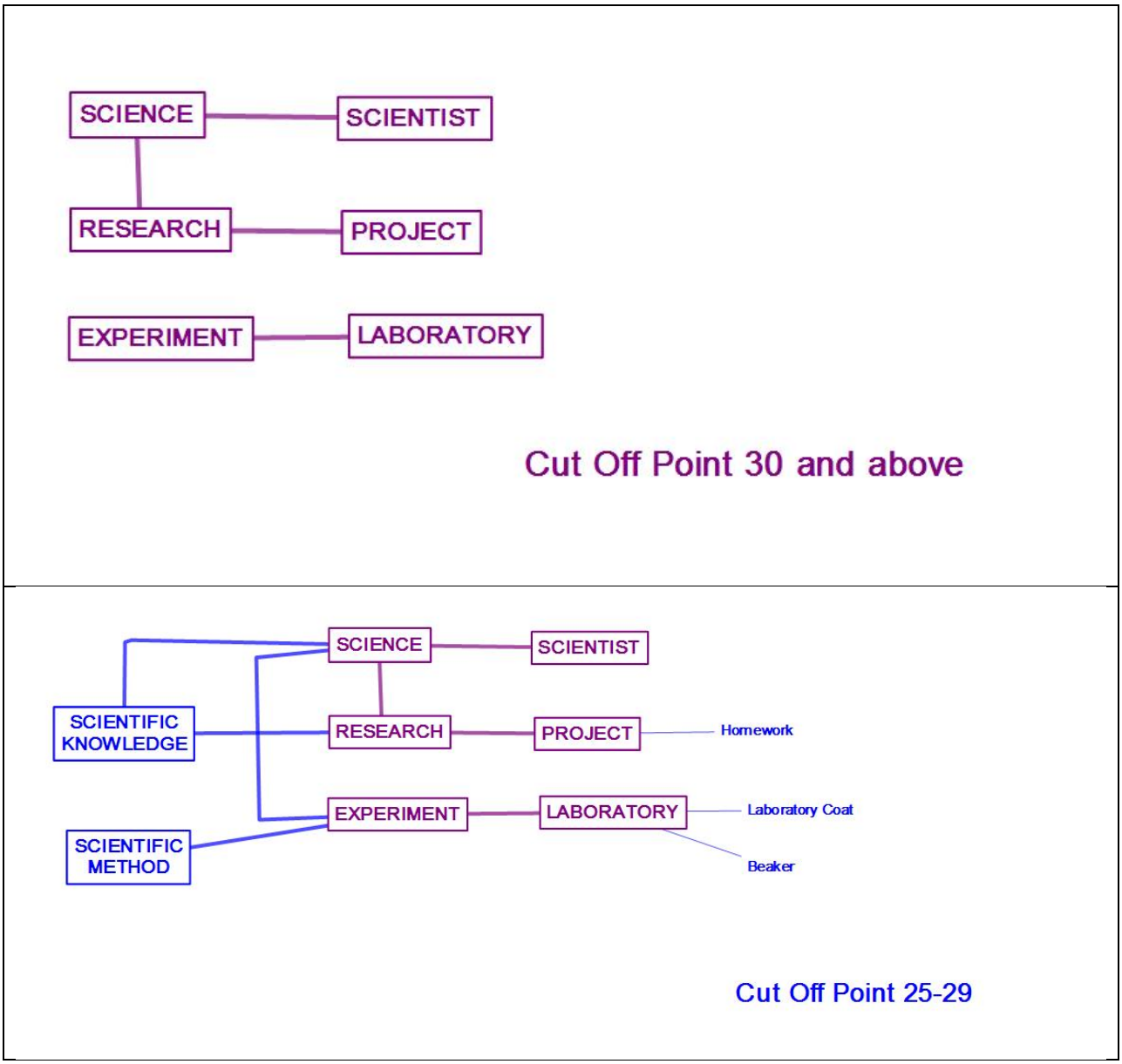
Cut-off point 15 - 19: Within this range, it was determined that each key concept was associated with at least two key concepts. Furthermore, words associated with all key concepts excluding *"scientific knowledge"* were observed.

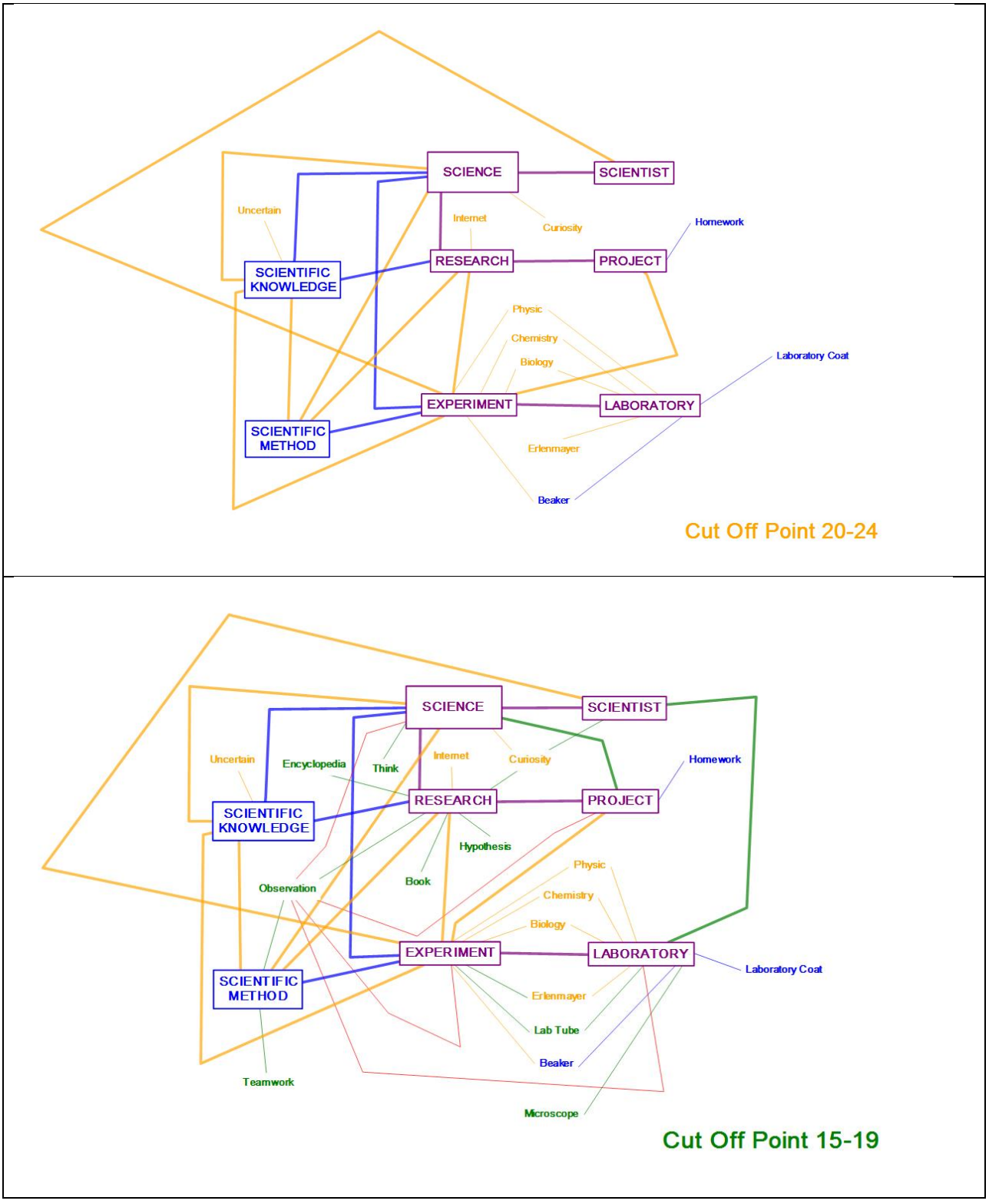
Within this range, associations were completed among "research" and "laboratory", "research" and "scientific method", "laboratory" and "scientist", and "experiment" and "scientist." Furthermore, the associations of *beaker, test tube, solution, curiosity, inventor* and *homework* were observed within this range.

Cut-off point 10 - 14: Responses were produced for all key concepts within this range and associations were made between "scientist" and "science", "scientist" and "scientific knowledge", "science" and "project", "scientific knowledge" and "scientific method, and "experiment" and "scientist". "*Science"* was associated with "*life"*. On the other hand, associations of "*chemical", "material", "microscope", "different way", "chemistry", "subject", "discover", "encyclopedia", "certain"* and "*provable"* were determined in this range. "*Scientific knowledge*" was associated with "*certain"* within this range. Therefore, misconception in relation to scientific knowledge was observed on the students.

Cut-off point 5 - 9: An increase in the number of words associated with the key concepts was observed within this range. Also, an increase was determined in the number of mutual response words that were associated with key concepts.

The concept networks that were prepared based on the pre-test word association test results after the project activity are given in figure 2.


SCIENCE
SCIENTIST
RESEARCH
PROJECT
EXPERIMENT
LABORATORY
Cut Off Point 30 and above
SCIENCE
SCIENTIST
SCIENTIFIC KNOWLEDGE
RESEARCH
PROJECT
Homework
EXPERIMENT
LABORATORY
Laboratory Coat
Beaker
SCIENTIFIC METHOD
Cut Off Point 25-29


SCIENCE
SCIENTIST
Uncertain
Internet
Curiosity
Homework
SCIENTIFIC KNOWLEDGE
RESEARCH
PROJECT
Physic
Chemistry
Biology
Laboratory Coat
EXPERIMENT
LABORATORY
SCIENTIFIC METHOD
Erlenmayer
Beaker
Cut Off Point 20-24
SCIENCE
SCIENTIST
Uncertain
Encyclopedia
Think
Internet
Curiosity
Homework
SCIENTIFIC KNOWLEDGE
RESEARCH
PROJECT
Hypothesis
Physic
Observation
Book
Chemistry
Biology
EXPERIMENT
LABORATORY
Laboratory Coat
SCIENTIFIC METHOD
Erlenmayer
Lab Tube
Beaker
Teamwork
Microscope
Cut Off Point 15-19

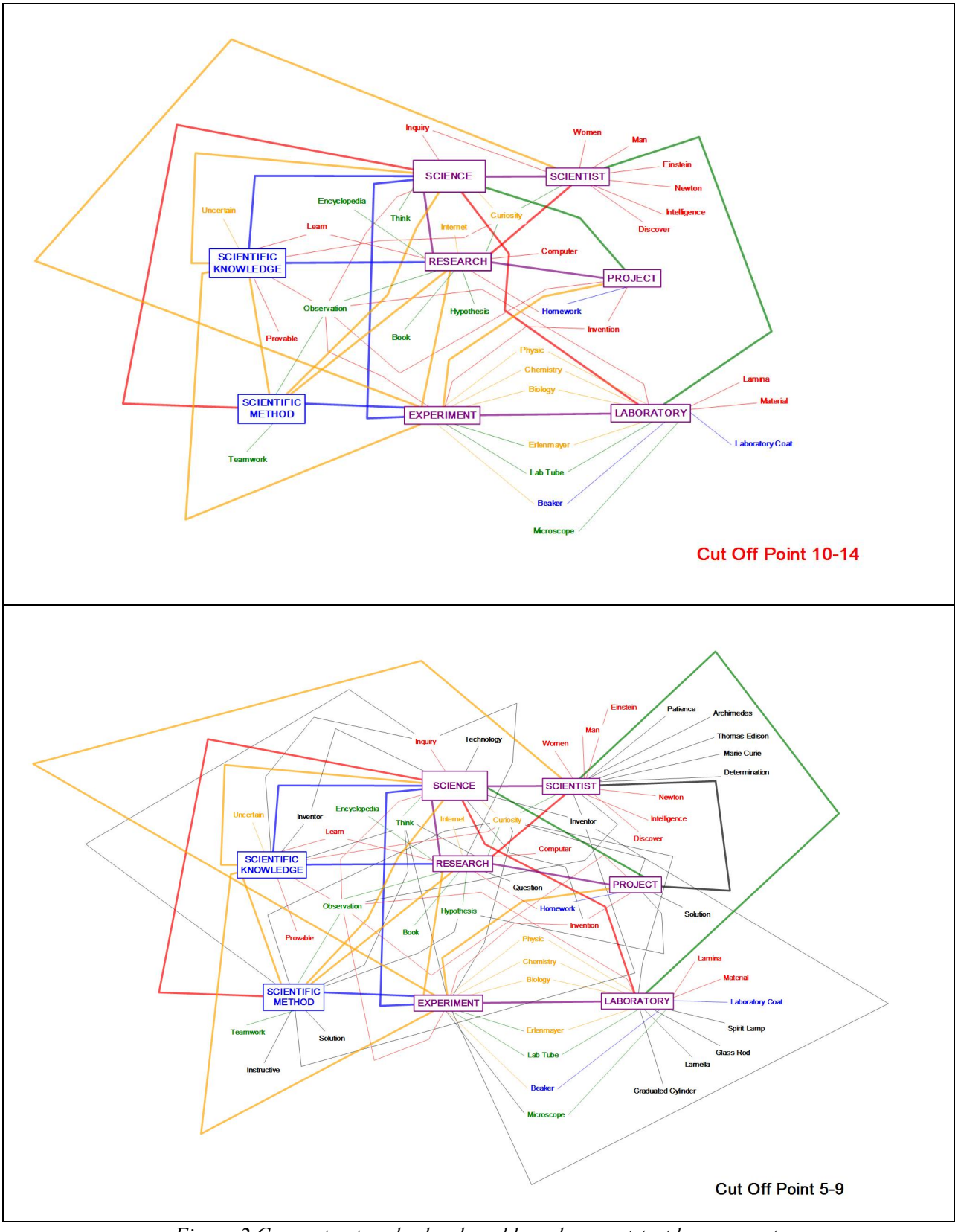


Figure 2.Concept networks developed based on post-test key concepts

Figure 2 can be interpreted as follows:

Cut-off point 30 and above: It was determined in this range that students made associations between more key concepts as compared to pre-test. "Project", "science" and "scientist" are seen in this range in the post-test as opposed to pre-test.

Cut-off point 25 - 29: In contrary to pre-test, all key concepts were observed within this range. Also, associations were made between "science" and "scientific knowledge" and "science" and experiment, "scientific knowledge" and "research", and "scientific method" and "experiment". In this range, the associations between "*project*" with "*homework*", and between "*laboratory*" with "*laboratory coat*" and "*beaker*" were observed.

Cut-off point 20 - 24: In this range, the link between key concepts was determined to be more complicated as compared to pre-test concept network. Furthermore, it was observed that the mutual responses to key concepts increased. The association that "scientific knowledge" is "not certain" was observed within this range. However, it was determined that the misconception (scientific knowledge is certain) in cut off range 10-14 in the pre-test, and it had been corrected in this range of the post-test.

Cut-off point 15 - 19: Responses were produced for all key concepts within this range. It was determined in this range that a higher number of words were associated with key concepts. It was observed that "*research*" and "*laboratory*" concepts are associated with concepts that are suitable for their nature. For instance, "*think", "hypothesis", "book" and "encyclopedia"* words were associated with the key concept of research.

Cut-off point 10 - 14: An increase in the number of words associated with the key concepts were observed within this range. However, "*man*" and "*woman*" words were associated with scientist concept. In other words, it was noticed that scientists have gender both woman and man.

Cut-off point 5 - 9: It was observed that *observation* and *curiosity* were associated with all of the key concepts. Therefore, it was determined that observation and curiosity were the most frequently used words. Nonetheless, it was observed in the responses to scientist key concept that the names of several scientists were written.

Conclusion and Discussion

Science curriculum mentions that scientifically literate individuals should have knowledge, skills, positive attitude, perception and values towards science (MNE, 2013). Therefore, scientifically literate individuals are expected to be familiar with the basic concepts about science In this study, concepts (science, scientific knowledge, scientific method, scientist, research, project, experiment and laboratory) that are in the science curriculum and WAT which consists of the scientific method concept that is frequently emphasized in project were used.

The results of the frequency tables obtained from WAT indicate that the overall conceptual association of students is at a good level. It was determined that the highest number of conceptual associations was made for the concept science (Table 1). The reason for this may be that science could have more connotations, as it is a more generic concept that contains other key concepts as well. It was determined that the responses produced to certain concepts were rather scarce. For instance, the number of responses for scientific method concept is less than others. As the reason for this scarcity, the fact that this concept is not included in the science curricula of 6^{th} and 7^{th} grade could be suggested.

It was revealed that the words associated with concepts in the frequency table (table 2) and concept network (Figure 1) of the pre-test are commonly used words by students in everyday life. For instance, scientist was associated with intelligence, Google, lab coat and similar materials in general. This association is also seen in the literature (Chambers, 1983; Fralick, Kearn, Thompson & Lyons, 2009; Lannes, Flavoni, & De Meis 1998; Medina-Jerez, Kyndra & Orihuela-Rabaza, 2011). It was determined that the words associated with concepts in the frequency table (table 3) and concept network (Figure 2) of the post-test are words that are more closely relevant to key concepts. For instance, while students associated science concept with its sub-branches such as physics, chemistry and biology in the pre-test, they opted for the word discovery in the post-test. The relevant literature has also determined association of the words physics, chemistry and biology (BouJaoude, & Abd-El Khalick, 1995) and discovery (Carey, Evans, Honda, Jay, & Unger, 1989) with science concept. Nonetheless, it was determined in the pre-test frequency table that elementary school students lack opinions regarding scientific knowledge being not absolute and being provable and based on life, learning and questioning. This result is in parallel to the relevant literature (BouJaoude, & Abd-El Khalick, 1995; Griffiths, & Barman, 1995). Lannes, Flavoni, & De Meis 1998; Newton & Newton, 1992).

Before and after project activity, the results of WATs indicated that students wrote more answers in the post-test as compared to pre-test. According to the concept networks prepared from frequency tables, it was determined that there were a higher number of associations between the key concepts in post-test concept networks as compared to pre-test concept networks; and the number of response words associated with key concepts increased. For instance, while students associated the concept scientist only with the names of a few scientists in the pre-test, it was determined that the number of examples for scientist names fairly increased in post-test. Furthermore, associations about that women could also be scientists were made in the pre-test.

It was observed that the misconceptions in the pre-test concept network were corrected in the post-test concept network. It was determined that the majority of students associated the scientific knowledge concept with exact knowledge in pre-test. In the post- test, the number of students who associated scientific knowledge with exact knowledge were two while the number of students who associated scientific knowledge with not being exact was 22. This circumstance is an indicator of the improvement in the cognitive structures of students at the end of project.

Participation of students in such extracurricular projects and similar activities give them the opportunity of cognitive development (Saxe, 1990 as cited in BouJaoude & Abd-El Khalick, 1995). Several researches in the literature also indicate that projects lead to an improvement in the cognitive structures, attitudes toward science and success rates of students (Gibson, & Chase, 2002; Knox, Moynihan, & Markowitz, 2003). Therefore, it is important to encourage students to participate in extracurricular activities.

Recommendations

Based on these research findings, the recommendations given below can be given for the results, curriculum developers, researchers, and science teachers.

This study was conducted with 6th and 7th grade students. Researchers who seek to study on the subject could increase the number of key concepts as the grade level is increased as well. Therefore, different concept networks can be obtained.

WAT technique could be used along with different techniques such as interview, concept map and drawing. Therefore, the variety of findings and associations obtained through WAT could be diversified.

A study in which WAT is supported with interview technique could help with detecting possible misconceptions of students in this regard. WAT was used as a data collection tool in this study. WAT could also be applied at the beginning of lessons so as to identify the readiness levels of students. WAT, which indicates the association between concepts and enables us to understand whether meaningful understanding took place, could be applied for different science subjects as well.

The concepts, which were determined to pose difficulty in respect to conceptual comprehension and association, could be emphasized more in lessons and curriculum.

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