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Pre-service Teachers' Metaphors Regarding the Concept of Scientific Thinking

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ABSTRACT The aim of this research was to analyze pre-service teachers' perceptions of the concept 'scientific thinking' through metaphors. Phenomenology, one of qualitative research designs, was used in the study. Participants of the study consisted of 180 pre-service teachers, including 146 females and 34 males and studying in different departments of the education faculty at Kocaeli University in Turkey, in spring semester of 2013-2014 academic year. They were asked to complete the sentence "Scientific thinking is like ..... because .....". The collected data was analyzed using content analysis technique. According to the findings, pre-service teachers produced a total number of 139 valid metaphors regarding the concept of scientific thinking. These metaphors were divided into 15 different conceptual categories in accordance with their common features. The results indicated that the pre-service teachers had multiple and distinctive perceptions regarding the concept of "scientific thinking".

INTRODUCTION

Metaphor, which means to carry or transfer, was derived from the Greek word metapherein (meta: beyond, above; pherein: carry). In his book called "Rhetoric", which is one of the first studies known to be about rhetoric, Aristoteles uses metaphor in its figurative meaning. According to Aristoteles (2004), metaphors are related to the original object but still they are inferred from things which are not so clearly related to it, just like the case in philosophy where a sharp wit understands the similarity between things which are very distant from each other. Jensen (2006) defines metaphor as a bridge that allows patterns of events, situations, relationships and connections in educational and social contexts. It is possible to consider metaphor as, in essence, the use of a concept or a phenomenon outside its actual meaning as a result of comparisons so that such concept or phenomenon is better understood.

Metaphors have attracted the attention of mankind throughout history and been universally used as part of the human life from the past to the present. They are at the center of many types of communication from everyday speech to political ideologies (Semino 2008). In recent years, a great deal of attention has been paid to metaphors in many areas, including politics (Burnes 2011; Matlock 2012), arts (Parsons 2010; Sinding et al. 2014), commercials (Gkiouzepas and Hogg 2011; Delbaere and Smith 2014), psychotherapy (Guloglu and Karairmak 2012; Liu et al. 2014), science (Arata 2014) and education (Arslan and Bayrakci 2006; Worley 2012; Pitcher 2014; Thomson 2015).

The studies conducted in the education field aimed to determine by which metaphors the respondents in the study group expressed concepts or phenomena such as 'a school' (Saban 2008a), 'teacher' (Saban 2004; Saban et al. 2006; Aydin and Pehlivan 2010), 'student' (Saban 2009; Aydin and Pehlivan 2010), 'classroom' (Uzun and Palic 2013), 'literacy ' and 'teaching literacy' (Shaw and Mahlios 2011), 'visual literacy' (Gocer and Tabak 2013), 'supervisorship' (Dos 2010), 'science and technology course' (Guler 2012), 'atmospheric pressure' (Kilinc and Tuna 2013), 'technology' (Koc 2013), 'geography' (Aydin 2010), 'cultural heritage' (Ay and Fidan 2013), 'reflective thinking' (Ersozlu 2013) and 'schooling' (Thomson 2015). As a result of the literature review, the researchers found no study related to the concept of "scientific thinking" in the literature.

Kuhn and Pearsall (2000) define scientific thinking as deliberate and controlled coordina-

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tion of theory and evidence. Martin (1997) suggests that judgments made by a scientist, a statistician or any person during the day are inductive reasoning used in scientific studies, while scientific thinking is a practical guide which helps making such inductive reasoning. Scientific thinking is not only related to science courses but also the applications for everyday life including which food to avoid, participating in recycling practices or not, what to do on the subject of climate change (Varma 2014).

The overall aims of Turkish National Education include raising all individuals as individuals with the power of scientific thinking. Determination of metaphorical perceptions related to the concept of scientific thinking of pre-service teachers, who will raise future generations with scientific thinking skills, reveals the importance of this work. This study is the first study in which metaphorical perceptions related to scientific thinking were determined.

Aim

The aim of this study was to analyze perceptions related to 'scientific thinking' of pre-service teachers studying in different departments of education faculty, through metaphors. For this purpose, answers were sought for the following questions:

1. Which metaphors related to the concept of "Scientific Thinking" do pre-service teachers from the departments of Science Teaching, Mathematics Teaching and Primary School Teaching develop?
2. Under which conceptual categories can the metaphors developed by pre-service teachers from the departments of Science Teaching, Mathematics Teaching and Primary School Teaching be grouped?

METHODOLOGY

Research Design

Phenomenology, one of qualitative research designs, was used in the study (Creswell 2007; Patton 2014). Phenomenology focuses on the phenomena which we are aware of but about which we have no in-depth and detailed understanding (Yildirim and Simsek 2013).

Study Group

The study group consisted of 180 senior students studying at Department of Science Teaching, Department of Mathematics Teaching and Department of Primary School Teaching in Education Faculty at Kocaeli University during spring semester of 2013-2014 academic year. Details of the study group are given in Table 1. Talkback form was distributed to 255 pre-service teachers in the study. However, 13 teachers returned the form blank and 62 pre-service teachers didn't provide satisfactory reasons for their metaphors in their forms or their written metaphors didn't match their indicated reasons so they were excluded from the study.

Data Collection Instrument

Data collection instrument of the study is a fill-in-the-blanks form which was developed by the researchers. It includes a section in which the metaphors to be generated and explanations regarding the metaphors will be written down.

Data Collection

In order to reveal the pre-service teachers' (who participated in the study) metaphors related to the concept of scientific thinking, they were given forms which says "Scientific Thinking is like ..... because ..... ". Before pre-service teachers wrote their metaphors, they were given explanations about metaphor and asked to concentrate on a single metaphor while completing the sentence "Scientific Thinking is like ..... because ....." In this study, the respondents were asked to write a reason for their own metaphors by including the word "because". They were given approximately 20 minutes to write their metaphors and the reasons for their metaphors. The forms completed by them comprised the data source for this study.

Data Analysis

Analysis of data obtained from metaphors developed by pre-service teachers was comprised of the following stages in the given order: coding, classification, category development, ensuring reliability and validity and transferring data to computer environment (Ozturk 2007; Saban 2008a; Saban 2008b; Ozder et al. 2012; Yalmanci and Aydin 2013). Coding was performed to determine to which pre-service teacher the respective metaphor belongs in order to facilitate data analysis. Accordingly, the following

coding was performed: Science Teaching (F), Mathematics Teaching (M), and Primary School Teaching (S); daytime education (1), evening education (2). For instance, if a metaphor was developed by a pre-service teacher from the department of science teaching and daytime education, the metaphor was coded as F1.

Validity and Reliability

Important criteria of validity in qualitative research include detailed reporting of collected data and the researcher's description of how s/he obtained the results (Yildirim and Simsek 2013). Specifically for this study, in order to ensure the validity of the results, data analysis process, the coding of respondents, frequency and percentage values and direct quotations are described in detail.

To ensure the reliability of the study, experts were consulted in order to confirm whether the metaphors given under 15 conceptual categories obtained in the study represent such conceptual categories. An academician from the department of educational sciences was given two lists, including an alphabetical list of 139 metaphor statements and a list of 15 conceptual categories. The expert was asked to match metaphorical images in list 1 with 15 conceptual categories in list 2 (so that none of the metaphorical images are excluded). Then, the matching made by the expert was compared with the researcher's own categories. By determining the number of consensus and divergence in the matching, the reliability of the study calculated using Miles and Huberman's (1994) formula (Reliability = consensus / consensus + divergence) was 90 percent.

RESULTS

The present study showed that pre-service teachers developed a total number of 139 valid metaphors regarding the concept of scientific thinking. Of these metaphors, 92 metaphors including the atmosphere (1) and oxygen (1) were generated by only one pre-service teacher, 14 metaphors including ocean (2) and the black hole (2) by two pre-service teachers, and the remaining metaphors, including space (11), the universe (7), light (7), a tree (4), a lantern (4), rainbow (4), the sky (4), infinity (4), a bulb (3), the moon (3), a child (3), a compass (3) and a star (3) by three or more pre-service teachers. The obtained metaphors for the concept of scientific thinking were grouped under 15 different categories. The metaphors and conceptual categories were presented in Table 2.

As presented in Table 2, the conceptual categories are listed as follows in the order of decreasing percentage of metaphors: An infinite phenomenon (18.9%), a phenomenon that provides guidance (17.2%), a phenomenon that provides versatile thinking (12.8%), a kinetic phenomenon (11.7%), a phenomenon that illuminates the darkness (8.3%), a phenomenon shaped by purpose (5%), a realistic / reliable / permanent source (4.4%), equal number of metaphors in the categories of a phenomenon that adds value to man, a phenomenon which is the source of life, and a valuable phenomenon (3.9%), equal number of metaphors in the categories of a phenomenon that brings happiness, a phenomenon that makes you explore and a phenomenon that provides peace (2.2%), equal number of metaphors in the categories of a phenomenon that is a food supply and a phenomenon providing solutions to problems (1.7%).

Some of the participant statements with their reasons for the use of metaphors regarding scientific thinking are presented below with direct quotations under the conceptual categories.

a. Scientific thinking as "An infinite phenomenon"

Several metaphors for scientific thinking were collected under the category of scientific think-

Table 1: Percentage distribution of genders of the study group by department

Department	*Female*		*Male*		*Total*
	n	*%*	*n*	*%*	
Science Teaching, daytime education	27	61	5	11	32
Science Teaching, evening education	30	68	1	2	31
Mathematics Teaching, daytime education	27	52	11	21	38
Mathematics Teaching, evening education	18	50	8	22	26
Primary School Teaching, daytime education	20	49	7	17	27
Primary School Teaching, evening education	24	63	2	5	26
Total	146	81	34	19	180

Table 2: Metaphor categories for the concept of "scientific thinking", the number of metaphors (NM), the total number of metaphors (TNM) and percentage (%) values

Category	*Metaphor*	*NM*	*TNM*	*%*
Category 1: Scientific Thinking as "An infinite phenomenon"	The atmosphere (1), a brain (1), a line (1), a state of conflict (1), the sea (1), the universe (6), the sky (3), the black hole (2), the ocean (2), an endless journey (1), infinity (4), outer space (1), space (9), road (1)	14	34	18.9
Category 2: Scientific Thinking as "A phenomenon that brings happiness"	Astronauts stepping on the moon (1), my favorite food (1), rainbow (1), hobby (1)	4	4	2.2
Category 3: Scientific Thinking as "A phenomenon that illuminates the darkness"	A bulb (1), an archaeological excavation (1), the moon (2), a lantern (2), the sun (1), light (2), t he first spark (1), a pencil (1), a torch (1), dawn (1), a star (2)	11	15	8.3
Category 4: Scientific Thinking as "A phenomenon that provides guidance"	A bulb (1), a key (2), mother (1), a mirror (1), a magnifying glass (1), a pair of binoculars (2), a lantern (1), rainbow (1), an eye (1), the sun (2), a treasure hunt (1), light (4), a torch (1), a microscope (1), a teacher (2), sparkling sea (1), a compass (3), questioning (1), water (1), awakening (1), a jigsaw (1), a star (1)	21	31	17.2
Category 5: Scientific Thinking as "a phenomenon adding value to man"	A bulb (1), having a privilege (1), rainbow (1), the sun (1), that you cry in a movie at which everyone laughs (1), time well-spent (1), a book (1)	7	7	3.9
Category 6: Scientific Thinking as "a phenomenon which is the source of life"	Exercise (1), internal organs (1), our heart (1), oxygen (1), a wood (1), water (1), a raindrop (1)	7	7	3.9
Category 7: Scientific Thinking as " A kinetic phenomenon"	A tree (2), tree branches (1), a baby (1), cycling (1) growing (1), a waterfall (1), a child (3), the universe (1), a sapling (1), speed (1), light (1), a book (1), magma (1), a tangerine (1), a knitted sweater (1), chess (1), a lightning (1), a kite (1)	18	21	11.7
Category 8: Scientific Thinking as "A phenomenon that provides versatile thinking"	I (1), multi-dimensional glasses (1), a mountain (1), a work of art on which detailed work has been done (1) critical thinking (1), philosophy (1), google (1), rainbow (1), the sky (1), an eye (1), a judge (2), camera (1), a labyrinth (1), rubber (2), a court (1) puzzle (1), hat technique (1), space (2), three-dimensional thinking (1), a route (1)	20	23	12.8
Category 9: Scientific Thinking as "A valuable phenomenon"	An antique (1), a precious stone (1), four seasons (1), interplanetary space (1), a mine (1), jewelry (1), stone (1)	7	7	3.9
Category 10: Scientific Thinking as "A phenomenon shaped by purpose"	Knife (1), bir far palet (1), a chameleon (1), a crippled bird (1), technology (1), a scales (1), a lame man (1), soil (1), Ying Yong (1)	9	9	5.0
Category 11: Scientific Thinking as "A phenomenon which is a food supply"	A tree (2), soil (1)	2	3	1.7
Category 12: Scientific Thinking as "A phenomenon which is a solution to problems"	an answer (1), a lantern (1), a machine (1)	3	3	1.7
Category 13: Scientific Thinking as a "Realistic / reliable / permanent source"	ATM (1), the moon (1), fathers (1), clear water (1), a mirror (1), a day (1), a dream (1), the first teacher (1)	8	8	4.4
Category 14: Scientific Thinking as "A phenomenon that makes you explore"	A bottomless pit (1), a labyrinth (1), a cave (1), poetry (1)	4	4	2.2
Category 15: Scientific Thinking as "A phenomenon that provides peace"	White flag (1), the universal language (1), intersection (1), an olive branch (1)	4	4	2.2
Total		139	180	100.0

ing as “an infinite phenomenon”. Some of the participant statements are like the following:

“Scientific thinking is like infinity. Because one idea leads to another. (F2)

“Scientific thinking is like the sky. Because we do not know the limit of things we can reach.” (S1)

b. Scientific thinking as “a phenomenon that brings happiness”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a phenomenon that brings happiness”. Some of the participant statements are like the following:

“Scientific thinking is like a hobby. Because you enjoy it.” (M2)

“Scientific thinking is like my favorite food. Because it always makes me happy and I always want to have it. “ (S1)

c. Scientific thinking as “a phenomenon that illuminates the darkness”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a phenomenon that illuminates the darkness”. Some of the participant statements are like the following:

“Scientific thinking is like light. Because it illuminates dark thoughts of man.” (M1)

“Scientific thinking is like an archaeological excavation. Because it unearths the past.” (F1)

d. Scientific thinking as “a phenomenon that provides guidance”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a phenomenon that provides guidance”. Some of the participant statements are like the following:

“Scientific thinking is like a pair of binoculars. Because it makes you see what you can’t see and opens up your horizon. “ (M1)

“Scientific thinking is like a jigsaw. Because as information which is accessible by scientific thought is completed, it gives us the unknown picture of humanity and the world. (S2)

e. Scientific thinking as “a phenomenon adding value to man”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a phenomenon adding value to man”. Some of the participant statements are like the following:

“Scientific thinking is like the sun. Because we are the moon; the more we get the light of the sun, the more we’ll shine. (S1)

“Scientific thinking is like time well-spent. Because we mature as we spend time well.” (F1)

f. Scientific thinking as “a phenomenon which is the source of life”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a phenomenon which is the source of life”. Some of the participant statements are like the following:

“Scientific thinking is like oxygen. Because life does not continue in its absence.” (M1)

“Scientific thinking is like exercise. Because mind needs it just like a body needs sports.” (S1)

g. Scientific thinking as “a kinetic phenomenon”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a kinetic phenomenon”. Some of the participant statements are like the following:

“Scientific thinking is like the universe. Because it is constantly expanding. “ (F1)

“Scientific thinking is like chess. Because every move is built on the previous one and you act within the rules.” (M2)

h. Scientific thinking as “a phenomenon that provides versatile thinking”

Several metaphors for scientific thinking were collected under the category of scientific thinking as “a phenomenon that provides versatile thinking”. Some of the participant statements are like the following:

“Scientific thinking is like a pair of multi-dimensional glasses. Because it allows you to see all the details in an area. “ (S1)

“Scientific thinking is like a labyrinth. Because they all appear to be identical, but they all lead us to a different place. (M2)

i. Scientific thinking as “a valuable phenomenon”

Several metaphors for scientific thinking were collected under the category of scientific think-

ing as "a valuable phenomenon". Some of the participant statements are like the following:

"Scientific thinking is like a mine. Because it gains value as work is carried out in it." (F2)

"Scientific thinking is like a stone. Because even if it breaks, its essence always remains in its parts. (M2)

j. Scientific thinking as "a phenomenon shaped by purpose"

Several metaphors for scientific thinking were collected under the category of scientific thinking as "a phenomenon shaped by purpose". Some of the participant statements are like the following:

"Scientific thinking is like soil. Because it has everything in it; it gives life to good ones; it revives them; it decomposes the bad ones within itself. (F2)

"Scientific thinking like a knife. Because if you use it appropriately, it is useful; if you use it maliciously, it is harmful. (M1)

k. Scientific thinking as "a phenomenon which is a food supply"

Several metaphors for scientific thinking were collected under the category of scientific thinking as "a phenomenon which is a food supply". Some of the participant statements are like the following:

"Scientific thinking is like a tree. Because as it turns green, it becomes a supply for other living things. (F2)

"Scientific thinking is like soil. Because as it becomes more productive, we eat well." (F1)

l. Scientific thinking as "a phenomenon which is a solution to problems"

Several metaphors for scientific thinking were collected under the category of scientific thinking as "a phenomenon which is a solution to problems". Some of the participant statements are like the following:

"Scientific thinking is like a machine. Because it makes our lives easier." (M1)

"Scientific thinking is like an answer. Because it can produce solutions to problems." (M2)

m. Scientific thinking as a "realistic / reliable / permanent source"

Several metaphors for scientific thinking were collected under the category of scientific thinking as "a realistic / reliable / permanent source". Some of the participant statements are like the following:

"Scientific thinking is like an ATM. Because it stores information to be given to everyone." (S1)

"Scientific thinking is like the first teacher. Because it gives the feeling that it is the most reliable source." (M1)

n. Scientific thinking as "a phenomenon that makes you explore"

Several metaphors for scientific thinking were collected under the category of scientific thinking as "a phenomenon that makes you explore". Some of the participant statements are like the following:

"Scientific thinking is like a labyrinth. Because you proceed on that route in curiosity and never know what will happen. (F2)

"Scientific thinking is like poetry. Because it is deep." (F2)

o. Scientific thinking as "a phenomenon that provides peace"

Several metaphors for scientific thinking were collected under the category of scientific thinking as "a phenomenon that provides peace". Some of the participant statements are like the following:

"Scientific thinking is like a universal language. Because it ensures peace." (M2)

"Scientific thinking is like an intersection. Because it brings people and communities together." (M1)

DISCUSSION

Metaphors produced by pre-service teachers were grouped under 15 different categories. When they were examined, it was observed that scientific thinking was regarded as an infinite phenomenon, a phenomenon that brings happiness, illuminates the darkness, provides guidance, provides versatile thinking, makes you explore and provides peace, a phenomenon adding value to man, a phenomenon which is the source of life, a kinetic phenomenon, a valuable phenomenon, a phenomenon shaped by purpose, a phenomenon which is a food supply, a phenomenon which is a solution to problems and a

realistic / reliable / permanent source. Similarly, Saban (2008b) found in his metaphor study on the concept of knowledge that primary school teachers and their students designated knowledge as "a valuable thing, something that provides guidance, something that develops, something that brings happiness, something that is a source of food, and infinity". These findings were found to be similar to the categories obtained in this study by content. Scientific thinking involves formulation of a variety of hypotheses and accordingly gathering information in the face of a problem (Dokme 2005). Therefore, a similarity can be thought to occur between knowledge and categories about metaphorical perceptions that have been developed with regard to the concept of scientific thinking.

Karacam and Aydin (2014) examined secondary school students' metaphorical perceptions of technology and discovered that the students developed 68 different metaphors regarding the concept of technology. There were a total number of 18 common metaphors between the two studies, including a tree, a lamp (bulb), mother, the moon, a baby, a chameleon, the universe, the sun, light, a pencil, a book, rubber, a machine, oxygen, a teacher, water, space, and a star. According to Cetinkaya (2006), in education system, what people understand from science is technology and technology products. The high number of common metaphors between this study regarding scientific thinking and the study by Karacam and Aydin (2014) on the concept of technology suggests that pre-service teachers also perceive scientific thinking as technology, as argued by Cetinkaya (2006) for science.

As Confucius, the famous philosopher, emphasized in his teaching "Learning without thinking is useless, thinking without learning is dangerous...", learning is a phenomenon that can be learned by thinking (Akinoglu and Tandogan 2007; Akinoglu 2008; Eren and Akinoglu 2013; Usak et al. 2013). Therefore, the requirement for developing students' thinking skills has arisen in education. Gelen (2002) studied whether 4th grade teachers were qualified to make their students gain thinking skills during social studies lesson, and determined that teachers thought that they were qualified to make students gain thinking skills, however, that they failed to do the same during the researcher's observations. The result of this study, in which the perceptions of scientific thinking was determined, is supported by the result of the study in the literature which established that teachers' qualifications to develop thinking and thinking skills are not satisfactory, because our respondents produced multiple and distinct metaphors. Thinking skills should be part of the curriculum for each course (Erktin 2002) so that pre-service teachers can make their students gain thinking skills when they actually begin to teach.

When teachers were asked to list thinking skills in the order of priority assigned by them in order to determine their approach to thinking education, they were found to give priority to the skills of logical thinking, creative thinking and subject-based effective thinking, and it was seen that scientific thinking skills were given average priority (Erktin 2002). In education, emphasis should be placed not only on thinking but also on the development of scientific thinking skills. As a result of a practice conducted by Mugaloglu et al. (2002) on the sixth graders using a program they've prepared in order to develop scientific thinking, they demonstrated that the processes of scientific thinking can be developed using programs prepared for this purpose. Zhong (2014) argued that scientific thinking can be developed by experimental practices in which scientific thinking methods are employed during experiment-based inorganic and analytical chemistry lessons. According to Zhong (2014), basic requirements of undergraduate students are making them gain and improve scientific thinking skills so that they have innovative consciousness and improve their innovative skills. The results in the literature indicating shortcomings related to scientific thinking at secondary school and undergraduate level support the results of this study, which determined that pre-service teachers have inadequate perceptions of scientific thinking.

CONCLUSION

The objective of this study was to analyze the pre-service teachers' perceptions towards the concept of "scientific thinking" through metaphors. It was observed that a large number of metaphors (139) were produced with regard to the concept of "scientific thinking" and 15 different conceptual categories were found in this study. The metaphors which were referred to the most with regard to the concept of scientific thinking were found to be the space, the uni-

verse and light; and they were mostly categorized as an infinite phenomenon a phenomenon that provides guidance, a phenomenon that provides versatile thinking, a kinetic phenomenon. The large number of the metaphors suggests that the pre-service teachers have very different perceptions of the concept of "scientific thinking". Also pre-service teachers' reasons for their metaphors related to scientific thinking were inadequate, suggesting that pre-service teachers should be trained on scientific thinking.

RECOMMENDATIONS

In this study, metaphor analysis was made using a form developed in qualitative research design. A similar study can be conducted on teachers and students at other levels of education and comparisons can be made between them. Furthermore, a study can be conducted on teachers and students using interview technique, and various opinions about scientific thinking can be revealed.

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