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An Investigation Of Pre-Service Science Teachers' Cognitive Structures and Ideas About The Nature Of Technology

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ABSTRACT

The purposes of this study were to investigate pre-service science teachers' cognitive structures and ideas about the nature of technology. The study was conducted with the participation of senior pre-service science teachers (N=41) in fall semester of 2007. The participants were enrolled in a science, technology and society course during data collection. Three instruments were used to gather data: a *word association test (WAT), Views about Technology Questionnaire (VTQ)* and an *interview protocol*. Participants' cognitive structures about technology were investigated by using WAT. Participants' ideas about the nature technology were also investigated by using VTQ and the interview protocol. The data triangulation provided a means of observing similar findings by using different instruments. The findings suggest that participants' cognitive structures about technology and their knowledge about definition of technology, ideas about the mutual interaction between technology and society, and ideas about social structure of technology were found to be at a lower level (naïve views). Notably, it was seen that the participants did not sufficiently discriminate between technology and science. In sum, they regard technology as a sub-discipline or output of applied science. They understand technology merely as computers, inventions and products of science, perhaps, due to their everyday experiences the way technology is presented news in mass media.

KEYWORDS: Nature of technology, preservice science teachers, cognitive structure

Fen Bilgisi Öğretmen Adaylarının Teknolojinin Doğası Hakkındaki Bilişsel Yapıları ve Görüşleri

ÖZET

Bu çalışma güz 2007 döneminde son sınıfta okuyan fen bilgisi öğretmen adaylarının (N=41) teknolojinin doğası hakkındaki bilişsel yapılarını ve düşüncelerini araştırmak amacıyla yapılmıştır. Veri toplama sürecinde katılımcılar bir fen, teknoloji ve toplum dersi almaktaydılar. Veri toplamada üç araç kullanılmıştır: *bir kelime ilişkilendirme testi (KİT), Teknoloji hakkında Görüşler Anketi (THGA) ve bir mülakat protokolü*. Veri sağlaması yapılması benzer bulgulara farklı yöntemlerle ulaşılmasını temin etmiştir. Bulgular şu sonuçlara işaret etmektedir: Katılımcıların teknoloji hakkındaki bilişsel yapıları ve teknolojinin tanımı hakkındaki bilgileri, teknoloji ve toplum arasındaki karşılıklı etkileşim ile teknolojinin toplumsal yapısı hakkındaki görüşleri düşük

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düzeydedir. Katılımcıların bilim ve teknoloji hakkında yeterince bir ayrım gözetemedikleri de ayrıca dikkate değer bir bulgudur. Katılımcılar, özde, teknolojiyi uygulamalı bilimin bir alt disiplini olarak görmektedirler. Teknoloji denince anlaşılan bilgisayarlar, icatlar ve bilimin ortaya koyduğu ürünler olmaktan öteye gitmemektedir. Bu durumun ortaya çıkmasında belki de en önemli rolü günlük deneyimler ve kitlesel medyada teknolojinin yansıtılış biçimi oynamaktadır.

ANAHTAR KELİMELER: Teknolojinin doğası, fen bilgisi öğretmen adayları, bilişsel yapı

INTRODUCTION

Today, for most of us, technology is a vital and inevitable part of our lives. The modern men and women are conducting their businesses by using all sorts of technologies. This dependence on technology is creating a new type of addiction. Due to its widespread use a great emphasis is being given to educating technologically literate generations, since "[c]itizens who understand and are comfortable with the concepts and workings of modern technology are better able to participate fully in society and in the global marketplace" (ITEA, 2003).

The vision of Turkish Science and Technology Curriculum has been ambitiously set as "educating all students as scientifically and technologically literate individuals whatever their individual differences might be." It is hoped that citizens having science and technology literacy can understand relationships and interactions between science, technology, society, and environment (MEB, 2005, p.5).

Many people immediately associate "technology" with computers and internet rather than its functional definition of "changing natural world to fulfill our needs" (Rose & Dugger, 2003, p.1). Studies indicate that technology mostly reminds electronic things and it only involves such things (e.g. Volk & Dugger, 2005). "Students have existing concepts of technological processes, such as problem solving and design cycles, and the different aspects of that process, such as modeling, skills, planning and evaluation. These existing concepts affect current technological practice, as well as future learning of technological concepts and process. Further research is required to further understand and change students' existing technological concepts." (Jones, 2002, p.88).

Jones and Carr (1992), determine that many elementary school teachers regard technology education as computers, using computer and using other technologies in problem solving. Also, Volk and Dugger (2005) studied that what Americans and Hong Kong people think about technology. They asked them some questions about technology. Their findings, for instance, are shown below:

- *When you hear the word "technology, what first comes to mind?*

	HK (%)	US (%)
Computers	47	68
Advancement	7	2

New Inventions	7	1
Electronics	5	5
Information	4	0
Science	3	1
Space	3	1
Things That Make Life Easier	3	0
Machinery	2	1
Internet	1	2
Education	1	1
Others	19	18

- *Which more closely fits what you think of when you hear the word "technology"?*

	HK (%)	**US (%)**
Computers and the Internet	34	63
The application of knowledge.....	66	36
Changing the natural world		
Don't know/refused	---	1

In addition, for a long time, technology has been widely defined as "applications of science." However, today, by putting aside this traditional paradigm, researchers are questioning what technology is and how it interacts with science and the society in a much deeper level (de Vries, 1996). "There is, in the minds of the public, an intimate connection between science and technology. Frequently the concepts of 'science' and 'technology' are conflated. In many newspapers or broadcasts the words are used almost interchangeably" (Barlex & Pitt, 2002, p.177). "Pupils and students' also say that technology is important for their lives. We have already seen that they can mention a whole lot of examples of artifacts, and apparently they recognize that all these artifacts together make an important part of their daily lives. Furthermore they mostly express the opinion that technology has a positive role in their lives. There are relatively few pupils that can give balanced opinions in which both positive and negative effects of technology are taken into account. This should worry us. It means that many pupils lack the ability to make a critical assessment of technology" (de Vries, 2005, p.107).

Jones (1997), state that in-depth researches are needed on students' understanding of technological concepts and processes and ways in which these concepts and processes can be enhanced. De Vries (2003), also highlight that researches are also rare on students' understanding of technological concepts.

Research Questions

The purpose of the study is to investigate of pre-service science teachers' cognitive structures and ideas about nature of technology. For this purpose, the following research questions of this study were identified.

I.What are the cognitive structures of pre-service science teachers about technology?

II. What are pre-service science teachers' ideas about,
a.Definition of technology?
b.Technology literacy?
c.Nature (features, qualities) of technology?
d.Relationship between technology and science?
e.Relationship between technology and society?
f.Inventors and scientists?
g.Technology education?

III. What are the implications for science teacher education?

METHOD

Participants

The study was conducted with the participation of 4th year pre-service science teachers (N=41) majoring in science education in fall semester of 2007. The participants were enrolled in a science, technology and society course during data collection.

Instruments

Three instruments were used to gather data in the study. These instruments were a *word association test (WAT),* the *views on technology questionnaire (VTQ)* and an *interview protocol*.

Word association test (WAT)

"Understanding how students acquire knowledge is always an important issue for science education researchers. Educators and cognitive scientist have tried to represent acquired knowledge in terms of cognitive structures" (Tsai & Huang, 2001). Word association test (WAT) is a method for investigating cognitive structure and many researchers have used the method for investigating of learners' cognitive structure (e.g. Taşar, 2001; Bahar *et al.*, 1999; Cachapuz & Maskill, 1987; Gussarsky & Gorodetsky, 1988; Johnstone & Moynihan, 1985; Shavelson, 1974).

Participants' cognitive structure about technology was investigated by using Word Association Test (WAT). In order to construct the WAT, ten words were selected by the researchers. These key words were *Technology, Design, Science, R & D (Research and Development), Invention, Discovery, Industry, Informatics, Scientist, and Inventor*. Each key word was written at the top of the page in WAT. Participants were required to write maximum ten responses for each key word that they recalled associated with that key word. Participants were given to write their response 30 seconds for each key word and time was controlled by the researchers. Participants' responses were analyzed by the researchers. In the analyze procedure, meaningful responses were accepted and counted for each key word than frequency table was prepared. Concept map was drawn by using

the frequency table. To draw concept map, highest frequency was determined. Then a cut-off point that was lower than highest frequency was determined. Cut-off point was lowered step by step and concept map was drawn for each step.

The Views about technology questionnaire (VTQ)

Participants' ideas about technology were investigated by using Views on Technology questionnaire (VTQ) and interview protocol. In order to construct VTQ, 16 questions related to technology were selected from *Views on Science-Technology-Society* (VOSTS) questionnaire improved by Aikenhead et al. (1989). These questions were consisted of four domains.

1. Defining technology, (1^{st}, 2^{nd}, 3^{rd}, and 4^{th} items)

2. Effect of society on technology, (5^{th} and 6^{th} items)

3. Effect of technology on society, and (7^{th}, 8^{th}, 9^{th}, 10^{th}, 11^{th}, and 12^{th} items)

4. Social structure of technology (13^{th}, 14^{th}, 15^{th} and 16^{th} items)

Each question of VTQ begins with a statement about technology topic. Next, there is a list of positions (or viewpoints) to choose about technology topic. A sample question from VTQ is shown below:

Defining what technology is can cause difficulties because technology does many things in Turkey. But MAINLY technology is:
Your position, basically: (Please read from A to J, and then choose one.)

A. Very similar to science.
B. The application of science.
C. New processes, instruments, tools, machinery, appliances, gadgets, computers, or practical devices for everyday use.
D. Robotics, electronics, computers, communication systems, automation, etc.
E. A technique for doing things, or a way of solving practical problems.
F. Inventing, designing and testing things (for example, artificial hearts, computers, space vehicles).
G. Ideas and techniques for designing and manufacturing things, for organizing workers, business people and consumers, for the progress of society.
H. I don't understand.
İ. I don't know enough about this subject to make a choice.
J. None of these choices fits my basic viewpoint.

In addition, in order to assess the participants' views, we used the same categorization system of views (namely informed, has merit, and naive) that exists in other related studies (e.g. Rubba, Bradford & Harkness, 1996; Tairab, 2001; Erdoğan, 2004). A panel of 7 experts and 3 researchers served to categorize the views about each item in the instrument (for the details of

categories of each item see Aydın, 2009). VTQ was adapted by using back translation method (Maneesriwongul and Dixon, 2004). VTQ was translated from English to Turkish then from Turkish to English and was matched by two field experts and was controlled grammar by two field experts before asked participants. So, content validity of the adapted instrument was provided. Also, VTQ was applied to 41 participants taken in pilot study in the first sense. As a result of the applications, the answers given by 42 participants to questionnaire including 16 items were analyzed. According to this analysis, among 656 (16x41) answers, merely 15 answers (2.28%) included one of the three choices which is repeated in all items of the questionnaire. This proportion is considerably lower than the proportions in literature (Rubba et. al., 1996 [10.03%]; Lieu, 1997 [5.93%]). Therefore, it was decided that this questionnaire could be used in evaluating the view of teachers on nature of technology. VTQ was analyzed for each participants' views such as informed, has merit, and naïve (see Table 1).

The Interview Protocol

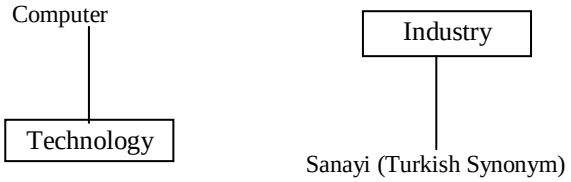
Interview was another way to investigate participants' ideas about nature of technology. In order to construct interview protocol, 12 semi-structured questions were selected about nature of technology. 7 participants were interviewed face to face by the researchers. Each interview was recorded 15 minutes approximately. Interviews were analyzed descriptively into seven research questions that were identified from literature. Each participant was coded with "P" (e.g. Participant-1:P1)

FINDINGS

Finding From Word Association Test (WAT)

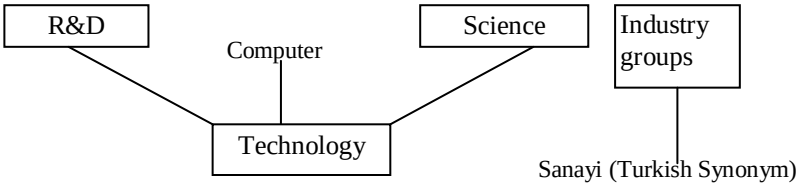
First cut-off point was determined as 25-up to draw concept map. Next, this cut-off point was lowered three times and following concept maps were drawn for each cut-off point. Concept maps for each cut-off point are shown below:

1- *Cut-off point 25-up*



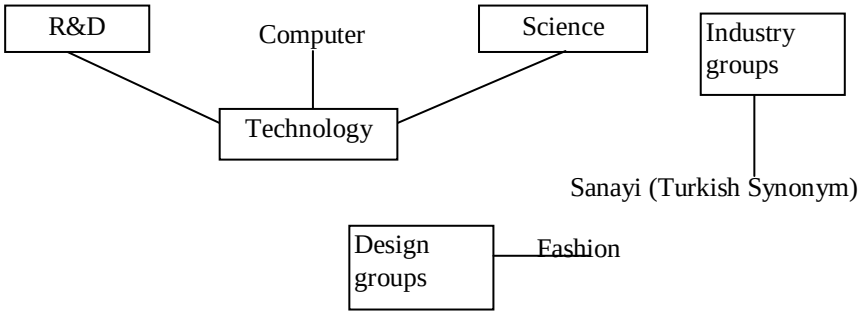
It is seen in the cut-off point 25-up that participants associated technology with only computer. The finding is shown that how participants' concepts are very poor related technology. And, because of "Sanayi" is Turkish Synonym of "Industry", this association is not regarded as significant.

2- *Cut-off point 20-24*



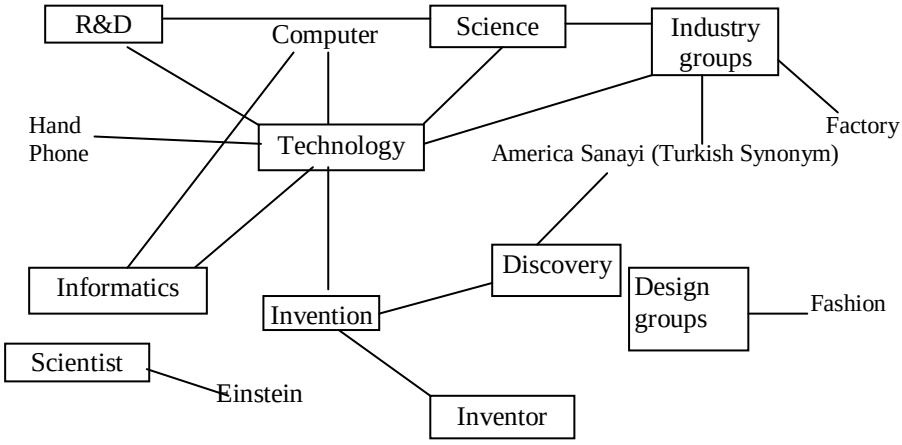
In this step, it is seen that participants' level of association is more comprehensive in respect of cut-off point 25-up. Even though this association is more comprehensive, it is also seen that this association is between technology concept and other concepts, not between other concepts mutually (e.g. science and computer, science and R&D, computer and industry)

3- *Cut-off point 15-19*



It is seen in the cut-off point 25-up that there is no significant difference between this step and cut-off points 20-24. In addition to cut-off point 20-24, participants only associated "Design" with "Fashion".

4- *Cut-off point 10 – 14*



In this step, it is seen that participants' level of association more comprehensive in respect of other steps. Even though this association is more comprehensive, proportion of participant is seen so low.

Finding from the Views about technology questionnaire (VTQ)

Second method of gathering data we used was VTQ. Participants' responses related to VTQ were presented in table 1.

Table 1. *Frequency of participants for each item from VTQ.*

		Categories		
Item No	*VTQ Items*	*Naive*	*Has Merit*	*Informed*
1	**10211** Defining of technology	17	5	18
2	**10311** Meaning of research and development	2	22	16
3	**10411** Relationship between science and technology	6	2	32
4	**10431** Relationship between science and technology	22	16	2
5	**20511** Effect of society on science and technology	5	3	32
6	**20521** Effect of society on science and technology	1	6	33
7	**40221** Relationship science, technology and moral decisions	19	7	14
8	**40231** Relationship science, technology and legal decisions	9	4	27
9	**40311** Trade-offs between the positive and negative effects of science and technology	10	9	21
10	**40413** Relationship science, technology and social problems	1	9	30
11	**40511** Effect of science and technology on society	2	22	16
12	**40531** Effect of science and technology on society	6	10	24
13	**80111** Usage decisions regarding a new technology	6	11	23
14	**80122** Usage decisions regarding a new technology	20	5	15
15	**80133** Usage decisions regarding a new technology	1	23	16
16	**80211** Control of technological developments	--	28	12

When findings are evaluated, it is seen that many of the participants selected naïve views in 3 of the 16 items (namely items 4, 7, and 14), has merit views in 4 of the 16 items (namely items 2, 11, 15, and 16), and informed views in 8 of the 16 items (namely items 3, 5, 6, 8, 9, 10, 12, and 13). And, participants have similar selection in item 1.

When we examine these items under 4 main domains (Aikenhead & Ryan, 1992), we reach the following findings:

1. Defining Technology (items 1, 2, 3, and 4): Participants have more naïve and has merit views than informed.
2. Effect of society on science and technology (items 5 and 6): Participants have informed views about this issue
3. Effect of science and technology on society (items 7, 8, 9, 10, 11, 12): Although participants have informed views it is seen that there are also naïve and has merit views.
4. Social structure of technology (items 13, 14, 15, and 16): Participants have more naïve and has merit views than informed.

In sum, although participants have informed views about some issues, when we examined participants' naïve and has merit views, it was seen that the informed views were not sufficient, especially for senior pre-service science teachers.

Findings from Interviews

Before the interview participants were asked whether or not they were enrolled in any course related the nature of science and technology. None of them were enrolled in such a course before.

The Views on the Definition of Technology

When participant views are examined about what technology is, it is seen that the views were in parallel with findings in VTQ and parallel with the weak views that are in the related literature. For example:

"Technology is a progressing science in my opinion. Technology can define as computers, inventions which facilitate life shortly." **(Excerpt 1, Interview P1, line 3-4)**

"Technology is applied science such as manufacturing a thing in industry." **(Excerpt 2, Interview P2, line 3)**

"Technology is an output of science. It is the results obtained trough science. Technology is the application of science." **(Excerpt 3, Interview P4, line 4-5)**

The Views on Technology Literacy

Participant identified technology literacy as characteristics of a person who technologically literate. But when participant views are examined, it is seen that the views were weak and not enough. For example:

"Technology literate is a person who uses technology to achieve his/her goals." **(Excerpt 4, Interview P2, line 7)**

"Technologically literate are people who make research and observation." **(Excerpt 5, Interview P3, line 8)**

The views on the Nature of Technology (Its features, qualities etc.)

When participant views are examined, it is seen that the views were parallel with the naive views that are in the related literature. However, it is seen that participants' views were not comprehensive. For example:

"The most important feature of technology is its development. If it does not develop, it is no more called a technology." **(Excerpt 6, Interview P4, line 13-14)**

"It is renewable. It can change for the better or also worse." **(Excerpt 7, Interview P1, line 16)**

The Views on Relationship between Science and Technology

Participants regard technology as sub discipline of science or depend on science. For example:

"The more science advances, the more technology develops. But they seem to be related terms" **(Excerpt 8, Interview P2, line 19)**

"I think science have emerged before. Technology depends on science." **(Excerpt 9, Interview P1, line 20)**

"Science has emerged before. Then, application of science was made. Because, science develops technology." **(Excerpt 10, Interview P7, line 22)**

The Views on Effect of Technology and Society Mutually

Participants could not put forward any significant views on this issue. Participants only express views that there is an effect of technology and society mutually. For example:

"Technology affects the society and society in turn forms the culture by the living styles. Did we have a computer culture 10-15 years ago? No, we did not." (**Excerpt 11, Interview P7, line 31-32)**

The Views on the Characteristics of Inventor and Scientist

When participants' views are examined it is seen that they could make a good discriminate between scientists and inventors. For example:

"Inventor is like a person who invents products and makes a revolution such as Einstein that could think in an extraordinary way. It is of course not possible to produce something without knowing mathematics and physics." **(Excerpt 12, Interview P6, line 36-38)**

"Scientist examines and studies in more detail. But I don't know. There is no different between." **(Excerpt 13, Interview P4, line 39-40)**

"I think inventor is a scientist but scientist has not to be an inventor." **(Excerpt 14, Interview P5, line 24)**

The Views on Technology Education

Participants put forth that technology education should take place in related field. For example:

"Technology education might not be the same in every field. It might be more for able or predisposed people." **(Excerpt 15, Interview P1, line 43-44)**

"In my opinion, it is much more reasonable for technology education to be in numerical fields." **(Excerpt 16, Interview P7, line 50)**

"Technology education should be given to willing people. Those not interested should not take technology education." **(Excerpt 17, Interview P5, line 39-40)**

CONCLUSION and IMPLICATIONS

It is seen that there are same results in gathered data by using word association test, views on technology questionnaire and interview protocol. The study suggests that participants' conceptual structures about technology are generally at the novice level. Additionally, it is also seen that participants' knowledge related defining technology, effect of technology on society, effect of society on technology and social structure of technology are at novice level. Especially, they identify that technology and science are same and they also think that technology is a sub discipline, output or applied of science. They understand technology as computers, inventions and result of science. It can be thought because of participants face with technology as electronically or mechanical things in their life. And, participants thought science and technology as non-separable and claimed that there could be no technology without science.

The findings of our study are quite compatible with the findings of literature and support them. For example, the findings of some researchers (Jones & Carr, 1992; Volk & Dugger, 2005; de Vries, 2005) have been supported our findings. However, the vision of Turkish Science and Technology Curriculum has been aimed to educate science and technology teacher in the framework of science-technology-society and environment (MEB, 2005). Thus, if science and technology teachers don't construct nature of science and technology in their mind significantly, they don't teach science and technology significantly. Consequently, it is important to understanding about nature of technology for teacher education.

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