JBSE
ISSN 1648-3898

THE SCIENTIFIC UNDERSTANDING LEVEL OF PROSPECTIVE SCIENCE TEACHERS

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Abstract. *Scientific understanding is important to science teachers. The way which science teachers use for explaining issues related to science also affects students' understanding of science. Therefore, as a measure of the prospective science teachers' understanding of science, their conceptions and descriptions on scientific issues compose the aim of this study. The views of 75 prospective science teachers who are selected by purposive sampling were probed about the meaning of scientific and being scientific, the scientific events, the scientific questions and the scientific knowledge through open ended questions. The results, which are based on significantly different categories, displayed that the prospective science teachers' understanding of scientific issues is generally based on the phenomenon and empirical based understanding and perceived features those address traditional view of science. Besides, they seem to have inadequate understanding of science regarding logical, relational, sociological and historical aspects. At the end some recommendations were proposed accordingly.*

Key words: *understanding of science, prospective science teachers, scientific issues.*

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Introduction

We all face many things that are related to science in our daily lives. The examples could be pieces of data such as 'sun light reaches earth in about 504.03 seconds', or laws, for example, the law of survival of the fittest, or theories, such as Darwin's theory of evolution, or thumb rules, such as 'put a lightning arrester on top of a high rise building' or 'take a pain killer when you have headache' as Raza (2009, p.211) gave. In order to understand these issues, and to adopt them in his or her life, one has to have a basic understanding of science. In other words, assimilating scientific information requires some conception of what science is all about and some special skills in evaluating the information one receives (Giere, 1991).

Thomas & Durant (1987) state nine arguments for promoting the public understanding of science namely; benefits to public, benefits to national economics, benefits to national power and influence, benefits to individuals, benefits to democratic government, benefits to society, intellectual benefits, aesthetic benefits and finally moral benefits. They also add that, although individuals will differ in their attitudes to each, the core subject underlying these arguments is the scientific literacy emphasizing the importance of some basic knowledge and skills of science and technology, particularly in the context of their own lives possessing the appropriate attitudes (Thomas & Durant, 1987, p.11)

The basic knowledge of science requires understanding of science and its characteristics which distinguish it from other non-scientific issues. It eventually comes to mind what the characteristics of a scientific issue are. Root-Bernstein (1984) postulated four categories namely logical, empirical, sociological and historical criteria. Among these categories the logical criterion is about the validation of the statements and the empirical criterion is about the experiences with nature and evidence. The sociological criterion

ISSN 1648–3898

is about the relationship of the statements with other theories or explanations in the other disciplines and the historical criterion is about the relationship of the statement within the same discipline. While the logical and empirical criteria both set out the conditions for the objectivity of scientific statements, the historical and sociological criteria address the rationality of the scientific statements (Duschl & Erduran, 1996, p.158-159).

Science Education and Prospective Science Teachers

It is the main responsibility of the science educators to help individuals to gain a better understanding of the scientific literacy by means of the efforts towards true understanding of the science and scientific issues (Hodson, 1999). Therefore, it is important for science teachers to improve the understanding of science and scientific knowledge in consistent with the curriculum by paying attention to the characteristics of the scientific knowledge. These characteristics may be defined as being reliable, dynamic (not stable), concluded with more than one way, imaginative, relational on which social and cultural settings are affective (Akerson & Volrich, 2006).

The social, economical and cultural interactions within the social dynamics changed the definition of science and thereby scientific knowledge. The scientific knowledge can be defined traditionally as certain, authoritative, discovered and etc. As opposed to the traditional definition, the constructivist epistemology defines science as theory laden and therefore depends on the hypotheses and observations, accepted by the community of scientists, build collaboratively, reliable and not stable. Aikenhead (1994) points out that, it is vital to take into consideration about the values of society and environment besides the values related to science and scientific knowledge in order to understand the interactions among science, technology, society and environment. According to Ryder and Leach (2006), it is highly important for science teachers to mention explicitly about the characteristics of the scientific knowledge in order to support their learning. However, they should prefer to follow the local terms and concepts in consistent with the curriculum rather than discussing the arguments put forward by historians, sociologists and philosophers of science.

The constructivist approach of science education, challenges teachers to create environments in which they and their students are encouraged to think and explore the scientific knowledge (Brooks & Brooks, 2001; Fosnot, 1996). Therefore, the constructivist science teaching plays a crucial role in effective science teaching (Pekel, 2008). On the other hand, Unal & Akpınar (2006) showed that, science teachers failed to create constructivist learning environment in their classrooms. Additionally, they claimed that in order to overcome teachers' use of didactics methods in science classrooms, teachers' understanding of science courses should be investigated. Since, as the design of the instruction that offers learners the opportunities to develop target skills about scientific data, evidence, theory and knowledge must also be formatted with teachers' mind (Duschl & Erduran, 1996). Therefore, it is important to figure out their readiness level or thoughts about science and scientific issues including the prospective science teachers.

Zembylas & Barker (2002) outline the factors resulting in negative emotions and perceptions of the prospective science teachers about science teaching such as discomfort, anxiety, alienation, fear about inadequate content knowledge in science and limited views about scientific work and past negative experiences from learning science in school. These negative perceptions also make the prospective science teachers view problems given in the context of the courses and in the real life situations differently (Özdoğan & Kula, 2007). Therefore true understanding of the content knowledge and the scientific works has important place in having a positive attitude both in science and science teaching.

Besides the content and the methods of science, it is also important to understand the nature of science in order to come to understand science (Ryder et al., 1999; Sormunen, 2004). There are numerous studies showing that either the prospective science teachers or their educators at university have an understanding of science at a quite low and problematic level (Irez, 2006; Lederman, 1992). In addition, there are studies concluding that prospective science teachers are not successful at relating the daily life issues to the content of science (Yılmaz, 2008; Balkan Kıyıcı 2008). In their study with the final year university students Ryder, Leach & Driver (1999) found that the students have struggles to articulate their views on science. Can (2005) also found out that prospective science teachers have wide but uncertain body of knowledge about science.

To sum up, the way the science teachers use for explaining issues related to science also affects the students' understanding of science in a directly proportional manner even if he or she does not do it explicitly (Tobin & McRobbie, 1997; Edmondson & Novak, 1993; Brickhouse, 1990). As explained above, the prospective science teachers' understanding of science -formally or informally constructed from a wide range of experiences (Ryder and et al., 1999)- and the scientific thoughts are effective on students' understanding (Ewer, 2001; Aydoğdu & Ergin, 2007). Moving from this point of view, as a measure of the prospective science teachers' understanding of science, their conceptions and descriptions on scientific issues compose the aim of this study. The scientific understanding of prospective science teachers were probed about the meaning of scientific and being scientific, the scientific events, the scientific questions and the scientific knowledge. Therefore, the main question and the sub-questions on which this research is structured hierarchically are:

- What is the scientific understanding level of prospective science teachers?

1. What is the prospective science teachers' understanding of the meaning of scientific and being scientific?
2. What is the prospective science teachers' understanding of the scientific events?
3. What is the prospective science teachers' understanding of the scientific questions?
4. What is the prospective science teachers' understanding of the scientific knowledge?

Methodology of Research

This research has simple descriptive survey approach. The simple descriptive survey approach is one-shot survey for the purpose of describing the characteristics of a sample at one point in time apart from the other approaches of survey research namely cross-sectional and longitudinal (Mertens, 1998, p.108). In this research simple descriptive survey is conducted for the purpose of describing the scientific understanding levels of a group of prospective science teachers.

Participants

Participants are prospective science teachers of a faculty of education from a state university in one of the cities located on the west of Turkey. Purposive sampling is used to select the participants. In purposive sampling procedure, it is assumed that the persons chosen possess the necessary information about the target population (Frankel & Wallen, 1996). In this research, the researcher assumed that 3rd year has a special place in science teacher education as prospective science teachers have completed the sets of basic science courses (Physics I-II-III-IV, Chemistry I-II-III-IV, Mathematics I-II and Biology I-II) and besides start to have courses about science teaching (such as Special Methods of Science Teaching I), science laboratory practices (Science Teaching Laboratory Practices I-II) and nature of science (Nature and History of Science). Therefore, the study was conducted with 75 volunteered prospective science teachers (average age of 21.8) who have already completed the 3rd grade and passed to the 4th (final) grade.

Instrument

There are many studies showing the difficulties in measuring the understanding of science regarding science as being a multi-faced subject (Deshpande, 2004; Harlen, 2000). Despite these claims, there are also pencil and paper surveys about undergraduate students' understanding of science (Fleming, 1988; Bell and Lederman, 1996). In order to collect data properly from a sample of 75 students, the question form was used in this study.

The question form has 7 open-ended questions without reference to any particular scientific context rather it includes explicit questions and items. There are studies claiming that asking explicit questions

ISSN 1648–3898

about science has many disadvantages such as the problem of reflecting the actual thoughts and capturing the same meaning about issues related to science (Leach, 1996). On the other hand, thinking of the participants as the science teachers' of the future, they are expected to have basic explanation skills related to science. Therefore, they were asked to give descriptions and make choices explicitly by indicating the reasons behind.

The form has four main parts aiming to investigate the meaning of being scientific, scientific events and questions and scientific knowledge. The first three part of the form has the same questions used in a previous study conducted by the researcher (Author, 2010). In that study, the questions were used in a semi-structured interview form and asked to secondary school students. Here, they were used to put forward the meaning of scientific and the understanding of scientific and unscientific events and followed by presentations of some events and questions to be defined if they were scientific or not. The items related to events and questions were derived from Leach (1996). These questions were adapted to the prospective science teachers considering their age level and experiences. The last part of the question form is about scientific knowledge. All questions were examined by one professor, two lecturers of science education and then revised accordingly. In addition, the questions were piloted on another group of 5 prospective science teachers for clarity and comprehensibility. Initially, the pilot participants were asked to read and answer the questions by themselves. Afterwards, the researcher interviewed each of the pilot participants about what they think each question means and suggesting ways of rewriting the questions if they are unclear. At the end, final revisions on the questions were done.

Data Analysis

The prospective science teachers answered the questions by filling out the question form. All of the responses were analyzed for each question in turn. In the analysis, the structures towards particular meanings, concepts and relations were tried to be figured out where it is necessary to establish these structures over the categories with the codes identifying them (Büyüköztürk et al., 2008). Therefore, the answers were examined to draw comparisons and distinctions according to their meanings in order to identify the codes. The answers were recoded in a two week interval. The level of agreement between these coding, considered as the reliability of the procedure, was found as 0.89. After that, the codes addressing the same structures were categorized. At the end of the analyses, the answers were grouped under 7 categories. These categories were adopted from Root-Bernstein's (1984) already mentioned scientific categories and features of epistemological reasoning claimed by Leach (1996). The categories are shown in Table 1 with their explanations.

Table 1. The categories used to identify the views of prospective science teachers.

Name of the Category	Explanation	Codes
PB* Phenomenon Based	Description of particular phenomena and possible explanations of the cause were sometimes not distinguished. Scientific explanations are mostly attributed to the nature of the phenomena.	scientific principles in nature, observing, researching, measuring, phenomena, natural events, having scientific content and etc.
RB* Relation Based	The manipulation of key variables is seen as the knowledge about the cause. Explanation and evidence are separated but the answer is thought to emerge in an unproblematic way.	having cause-effect relation, investigating relationship, affecting other things, something that can be explained by its causes
LB+ Logical Based	If an explanation includes unnecessary ideas or is inconsistent, it can't really explain anything. Without falsifiable, it is impossible to tell if it is true or not, so we correct it via experimentation.	based on real things, physical realities, consistent, being objective, valid under specific conditions, critical thinking, subjective (for unscientific)

Name of the Category	Explanation	Codes
EB+: Empirical Based	A scientific explanation helps us understand the nature of our data. Some data may be factual; some may be artifactual; some are anomalous; some are irreproducible (thus invalid); and some are irrelevant.	being proven, proven data, justified knowledge, experimental, controllable
SB+ Sociological Based	Science is done by a community of researchers and that many scientific problems are discovered by the community. A scientific issue must address a genuine problem and must offer a means of resolving it.	producing new things, useful to people and humanity,
HB+ Historical Based	A scientific explanation does not just solve a problem, but must do so in a way that is superior to others. It explains more data than the other kind of explanations, so they have explanatory power.	something that is accepted universally
PF* Perceived Features	The perceived status such as beliefs, other kind of knowledge and pseudoscientific characteristics addressed are effective to consider an issue scientific.	cumulative of knowledge, certain result, being certain, stable, being about belief (for unscientific)

* Leach (1996); + Root-Bernstein (1984).

The qualitative data analysed through categories and codes which are explained in Table 1 were evaluated by using descriptive statistics and tabulated accordingly. The prospective science teachers' answers to meaning of scientific and being scientific (Table 2, 3), scientific events (Table 4), scientific questions (Table 7) and scientific knowledge (Table 10) were presented in the related codes and categories with the numbers and percentages which are calculated over 75 participants.

In this research, the prospective science teachers' understanding of science is held as categorical data. Therefore, The Chi-Square test, which is used to analyze the reported data in categories (Frankel & Wallen, 1996; Ferguson & Takane, 1989), was used in order to test if the prospective science teachers' understandings of science regarding meaning of scientific and being scientific, scientific events, scientific questions and scientific knowledge differ significantly on the basis of the defined categories.

On the other hand, answers to questions about categorizations of scientific events (Table 5) and questions (Table 8), reasons for selecting events (Table 6) and questions (Table 9) to be scientific were analysed by introducing measures called "rate of being scientific" and "rate of being unscientific". Since a participant was able to select more than one event or question as scientific, the preferences of prospective science teachers for scientific events and questions were analysed by calculating rate of being scientific. In the same way, since they stated sometimes more than one reason for an event or a question to be scientific or unscientific their reasons were analysed by calculating both rate of being scientific and rate of being unscientific. The rate of being scientific or unscientific for a group of events or questions is the percentage of the prospective science teachers who choose the event or question as being scientific or unscientific in the whole group (N=75).

Results of Research

The Meaning of Scientific and Being Scientific

The first question is about the meaning of scientific and being scientific. The codes and the categories for the meaning of "scientific" with the number of the participants agreed on, their percentages are given in Table 2. The Chi-Square test results for testing if the prospective science teachers' understandings of meaning of scientific differ significantly based on the defined categories are also presented in the table.

ISSN 1648–3898

Table 2. The categories and codes for the meaning of scientific and the chi-square test results.

Categories	Codes	N	%
PB	scientific principles in nature, conducting research	30	43
PF	cumulative of knowledge, certain result	25	33
EB	proven data, justified knowledge	17	23
LB	real things	3	4
	Total	75	100

Chi-Square	df	p
22.227	3	0.000

As seen, most of the participants understand that the word scientific is based on phenomenon and is followed by perceived features. More than one fifth of the participants could associate the meaning of scientific with a procedure including a kind of justification in an empirical sense. Only very few of the participants had a logical based understanding about the meaning of scientific mentioning the reality of the issues covered by science. As seen, the difference between the categories of the meaning of scientific is significant ($\chi^2(3) = 22.227$, $p<0.05$).

The participants' understanding of the meaning of scientific is also investigated by asking them about the meaning of "being scientific". The results including The Chi-Square test are given in Table 3.

Table 3. The categories and codes for the meaning of being scientific and the chi-square test results.

Categories	Codes	N	%
PB	Being about scientific studies, natural events	36	47
EB	Being proven	28	37
LB	Being objective	6	8
SB	Producing new things, useful to people	3	5
PF	Being certain, stable	2	3
	Total	75	100

Chi-Square	df	p
66.933	4	0.000

The answers on being scientific reveal that almost half of them had phenomena based understanding. In the second order, there is empirical based understanding stating the importance of the evidence. Afterwards, the views turn on logical and sociological based understandings and perceived features. It is also seen that the difference between the categories of the meaning of being scientific is significant ($\chi^2(4) = 66.933$, $p<0.05$).

The Scientific Events

The third question asked to give their own examples of scientific events and then put forward the reasons for differentiation. The examples grouped according to the reasons and The Chi-Square test results are given in Table 4.

Table 4. The examples of scientific events grouped by the reasons and the chi-square test results.

Categories	Codes		N	%
PB	Researchable, measurable, practicing		28	37.4
EB	Experimental, controllable, proven by experiments		21	28
LB	Objective, valid under specific conditions		16	21.3
RB	Having cause-effect relation, investigating relationship		6	8
PF	Containing certain result		3	4
SB	Useful to humanity		1	1.3
		Total	75	100

Chi-Square	df	p
47.160	5	0.000

The above results suggest that the participants' own examples of scientific events are mostly based on phenomena itself which is followed by empirical and logical based views. Besides, relational and sociological based understandings and perceived features take place in lower ratios. The result of The Chi-Square test indicates that there are significant differences between the categories of scientific events ($\chi^2(5) = 47.160$, $p<0.05$).

The participants were also asked to categorize six events as scientific or unscientific by giving reasons. Table 5 gives ratios of the events preferred as scientific by prospective science teachers.

Table 5. The prospective teachers' categorization of events to be scientific.

Events	rate of being scientific
Observing and drawing the moon's phases at every night.	75/75 (100%)
Measuring the temperature of the water with thermometer.	71/75 (95%)
Investigating the relationship between smoking cigarettes and risk of having heart attack.	67/75 (89%)
Observing the behaviours of the worms in rainy days.	54/75 (72%)
Buying the greenish apple from bazaar.	11/75 (15%)
Studying lesson by listening to music.	3/75 (4%)
All of the above statements are scientific.	2/75 (3%)

The rate distribution exhibits that all of the participants agree on events including "observing" to be scientific. Besides, 95% of the participants also agree on event about "measuring" to be scientific. "Investigating relationship" is also the mostly rated event (89 %) to be scientific. In the fourth order, there is again an "observing" involving event about worms (72%). Interestingly, while only 15% of the participants claimed that event involving "buying" to be scientific only 4% proposed "studying" to be

ISSN 1648–3898

scientific. Besides, only 3% of the participants view all of the events to be scientific. The ratio distributions for the reasons of the participants' preferences are given in Table 6. Most of the participants gave more than one reason.

Table 6. The distribution of scientific and unscientific reasons for the events.

Scientific			Unscientific		
Category	Codes	rate of being scientific	Category	Codes	rate of being unscientific
PB	Observing, researching, measuring	75/75 (100%)	No answer	-	31/75 (41.3%)
			LB	Subjective	29/75 (38.6%)
			PF	Not suitable for being re-searched	8/75 (10.6%)
EB	Experimenting	15/75 (20%)		Religious	1/75 (1.3%)
PF	Concluding a certain result	6/75 (8%)		No certain result	1/75 (1.3%)
SB	Producing knowledge	4/75 (5.3%)	PB	No measurement	3/75 (4%)
RB	Affecting other things	2/75 (2.7%)	SB	Harmful	2/75 (2.6%)

It is seen that all of the participants' basic reason for considering event scientific is phenomenon based (100%). This understanding is followed by empirical based understanding (20%). However, the rest of the participants' answers rely on perceived features (8%), sociological (5.35) and relation based (2.7%) understanding. On the other hand, it is interesting that 41.3% of the participants could not answer about why they found the events unscientific. However, among the responses, it is the logical based reason for showing the unscientific as subjective by 38.6% as in the top order. This is followed by the perceived features (total of 13ç20%), phenomenon (4%) and sociological (2.6%) based understanding.

The Scientific Questions

After asking about the scientific events, the participants were asked to give examples of scientific questions with the reasons behind.

Table 7. The examples of scientific questions grouped by the reasons and the chi-square test results.

Categories	Reasons	N	%
EB	Experimenting, proving	35	47
PB	Requires investigating, having scientific content	21	28
No answer	-	6	8
LB	Being about real, universal issues	5	7

Categories	Reasons	N	%
PF	Certainty, concluding a quantitative certain result	4	5
SB	Productive, producing knowledge	3	4
RB	Cause-effect relation	1	1
	Total	75	100

Chi-Square	df	p
88.613	6	0.000

As seen from Table 7, approximately half of the participants claim that, questions based on empirical findings with reasons of experimenting and proving are scientific. Phenomenon based understanding follows this group of reasons (28%). Afterwards logical based understanding and stating no reasons take place. It is seen that sociological and relational based understanding is represented in quite lower ratios. The Chi-Square test result indicates that there are significant differences between the categories of scientific questions ($\chi^2(6) = 88.613$, $p<0.05$).

The participants were also asked to classify ten questions whether they are scientific or not with their reasons. Their categorization with ratio distribution is presented in Table 8.

Table 8. The categorization of questions to be scientific.

Questions	rate of being scientific
What kind of bacterium is there in the water?	73/75 (97%)
How did the Earth occur?	67/75 (89%)
Is the Earth's atmosphere getting warm?	66/75 (88%)
How do migratory birds find their ways for flying to long distances?	65/75 (87%)
What kind of diet should be given to babies for keeping their health?	63/75 (84%)
What kind of fabric is waterproof?	57/75 (76%)
Is it wrong to fish the dolphins just for having fun?	14/75 (19%)
Which one is more profitable for buying washing powder in small or big packages?	14/75 (19%)
Do the ghosts appear in old houses at nights?	6/75 (8%)
Which is the best program on TV?	5/75 (7%)
All of the above questions are scientific	2/75 (3%)

This categorization shows that almost all of the participants (97%) state the first question to be scientific. Following this question, participants find the questions about the Earth (89%), the temperature

ISSN 1648–3898

of the Earth's atmosphere (88%) and the migratory birds (87%) to be scientific almost in equal turnouts. These are followed by the diet kind of babies (84%) and the kind of waterproof fabric (76%). Nearly one fifth of the participants find the questions about dolphins (195) and buying washing powder in various packages (19%) are found to be scientific in the same ratios. The least ratios were given to the questions about ghosts (8%) and best TV program (7%) to be scientific. There are also two participants (3%) claiming that all of the questions are scientific. The ratios for the reasons behind the choices were given in Table 9. Some of the reasons overlapped.

Table 9. The distributions of scientific and unscientific reasons for the questions.

Scientific			Unscientific		
Category	Codes	rate of being scientific	Category	Codes	rate of being unscientific
PB	Requires investigation, having topic related to natural science	62/75 (82.6%)	LB	Subjective, personal	70/75 (93.3%)
PF	Needs hard base of knowledge	20/75 (26.6%)			
LB	They all need to considered critically, requires criterion to be answered	19/75 (25.3%)	PF	Belief	15/75 (20%)
No answer	-	10/75 (13.3%)			

The reasons reveal that the participants mostly see the questions in phenomenon based approach (82.6%) as scientific. Nearly 27% of the participants thought of knowledge in perceived features. In addition, around one fourth of the participants (25.3%) think of critical thinking and the necessity of criterion for scientific questions. However, more than one tenth of the participants (13.3%) could not able to give any reason for the questions indicated as scientific. The reasons for claiming the questions as unscientific are mostly based on logical reasons (93.3%) such as finding the questions as subjective and personal. On the other hand, one fifth of the participants (20%) find the questions unscientific as they think they are about perceived features such as belief.

The Scientific Knowledge

The last question asked about scientific knowledge. The understandings of scientific knowledge with reasons and The Chi Square Test results were presented in Table 10.

Table 10. The descriptions for the scientific knowledge and the chi-square test results.

Category	Codes	N	%
PB	Something accepted on investigation, about science, natural settings	39	52
EB	Something proven by experiments	18	24
No answer	-	9	12
HB	Something that is accepted universally	6	8

Category	Codes	N	%
RB	Something that can be explained by its causes	3	4
	Total	75	100

Chi-Square	df	p
54.400	4	0.000

It is seen that, more than half of the participants had phenomena based understanding about scientific knowledge. Besides, nearly one fourth of the participants define scientific knowledge on the grounds of experiments. In addition to these, 12% of the participants could not define scientific knowledge. The rest defined the scientific knowledge as something that is accepted universally (historical based) and that can be explained by its causes (relational based). The result of The Chi-Square test indicates that there are significant differences between the categories of scientific knowledge (χ^2 (4) =56.400, $p<0.05$).

Discussion

There are many studies conducted to determine the views of prospective science teachers' understanding about science and science related issues (Irez, 2006; Orman 2002, Ryder and Leach, 2006). This study aimed at investigating the prospective science teachers' scientific thoughts through their written answers through reflecting the meaning of science which would be their subject of teaching in the near future. The results are discussed below in order to conclude the profile of the prospective science teachers regarding their understanding of science and scientific issues.

The Meaning of Scientific and Being Scientific

It is seen that the prospective science teachers' understanding about meaning of scientific rely on phenomena based, perceived features, empirical and logical based understandings (Table 2). In addition, their understanding about the meaning of being scientific spreads over phenomena, empirical, logical, sociological based and perceived features categories (Table 3). These observed categories found to be significantly different to reflect the understanding of the prospective science teachers about the meaning of scientific and being scientific (Table 2 and Table 3 respectively). The relative positions of these categories are discussed below.

First of all, it is seen that the majority of the prospective science teachers understand the meaning of scientific and being scientific based on phenomena such as conducting research, being related to nature, scientific principles in nature and knowledge (Table 2 and 3). However, more than one fifth of the prospective science teachers explained about the meaning of scientific and being scientific on the empirical grounds.

When we look at the results generally, they may indicate that the majority of the prospective science teachers have difficulty in articulating the science through the procedural terms rather they prefer the phenomena where the "science" involved in. In their study with the final year university students Ryder and et al. (1999) found similar results indicating that the students tended to view knowledge claims in science as provable beyond doubt using empirical data alone with struggling to articulate their views about science.

It is also interesting that a considerable number of prospective science teachers (33%) associate the meaning of scientific with cumulative knowledge, certain result and etc. In the perceived feature category (Table 2) in a traditional manner. In her study, Can (2005) found out that the prospective science teachers, who view the science as the cumulative knowledge has traditional view of both science and science teaching. This may be due to the fact that they see the science as a collection of facts, theories

ISSN 1648–3898

and laws (Martin, 1997). All of these factors address the traditional view of science. In traditional view of science and science teaching, science teaching is seen as lecturing or accurate telling of scientific facts without any consideration of cognitive aspects of learning as science teaching is the transmission of knowledge (Dana et al., 1997). The effects of the methodology which are used in basic science courses such as physics, chemistry and biology where the scientific principles are mostly taken into account may be seen as the reason for this finding. Therefore, the methods used by the professors at the faculty should be investigated.

Besides, minority of the prospective science teachers could express about the logical and sociological dimensions of meaning scientific. This result is thoughtful since it may indicate that the prospective science teachers are not able to infer that science is a form of logic and has complex social structure (Raykova, 2008). Moreover, this result may also show a lack of logical and social dimensions of science in prospective science teachers' understanding of science when Desphpande's (2004) emphasis on the use of word "scientific" is taken as determiner to measure the scientific attitude as a way it is developed. Similarly, the results of the surveys conducted by National Science Foundation (2004) revealed that two-thirds of the adult participants failed to explain what is meant by the scientific in their own words.

Therefore, these results may be evaluated as the prospective science teachers do not have a general approach about being scientific as scientific attitude. At that point, it is believed that the science teacher education program needs to be revised about to what extent they are successful at growing with science teachers with scientific attitude as this result indicate a theoretical-weighed science teacher education program (Turgut, 2009; Irez, 2006). This may also resulted from the content-based curriculum of school science from the early years of education. Irez (2006) in his study with the prospective science teacher educators also pointed out that the content-based curriculum and university entrance exams may be responsible for the poor understanding of science and of nature of science among the prospective science teachers.

The Scientific Events

When Table 4 is examined, it is seen that the prospective science teachers have understanding of scientific events extending over phenomena, empirical, logical based, relational, sociological and perceived features based understandings. These categories defining the prospective science teachers' understanding of scientific events were found to be significantly different (Table 4). In other words, the difference observed between phenomena based category which is the most predominant and sociological based category which is the least predominant is significant for their examples of the scientific events. The general discussion related to the prospective science teachers' perspective of the scientific events are as the following.

The prospective science teachers exhibit phenomena based understanding for the scientific events in majority (Table 4, 5 and 6). The findings indicate that the prospective science teachers evaluate the events in a phenomenon based perspective in favour of the words such as "observing", "moon" immediately. On the other hand, more than one fifth of the prospective science teachers view the science related events as testable on empirical grounds (Table 4, 6). These turnouts for both understandings show that the prospective science teachers think of the events scientific by considering their apparent features rather than the way used for explaining or understanding them. In their study, Boo & Toh (1998) found out that the fourth year university students had perceptually dominated thinking that means their understanding of scientific things are based only on the observable features in the various situations.

On the other hand, although more than one fifth of the prospective science teachers gave logically based examples (Table 4), only few of them seem to be aware that all of the events are scientific since they all needed to be filtered critically (Table 5). Besides, while only few of the prospective science teachers gave relation based examples (Table 4), 89% of the prospective science teachers agreed on investigating the relationship between smoking cigarettes and risk of having heart attack to be scientific that was a typical relational question (Table 5). Furthermore, only few of the prospective science teachers explained the reasons behind scientific events as relational (Table 6). After having similar results, Ryder and et al. (1999) reached the conclusion of inadequate understanding of science. They explained the emphasis of undergraduate courses on "ready-made science" as opposed to "science in the making" for this result.

It is also seen the prospective science teachers have the traditionally perceived features in lower ratios (Table 4, 6). In addition to these, very few of the prospective science teachers emphasized the sociological dimensions of the events in a limited manner (Table 4, 6). It is also interesting that, they do not tend to think the social events in relation with buying and studying to be scientific (Table 5). Boo and Toh (1998), claimed that their research result of the fourth year university students' lacking in ability to use scientific concepts may be due to the rote application of the concepts during the courses. This finding is parallel to the researches showing that level of relating science to daily life is very low and problematic for the prospective science teachers (Yılmaz, 2008; Balkan Kıyıcı, 2008) and the people in general (Clough and et al., 2005; European Commission Report, 2001) regarding the social aspects of science. The insufficient understanding of science regarding the social, historical and cultural dimensions may result from the fact that neither knowing besides learning science were taken as aspects of culturally and historically situated activity nor they were discernible as changing participation in changing social practices (Roth & Lee, 2002). Therefore, the social aspects of the science and scientific issues should be emphasized and the science concepts should be extended explaining the everyday phenomena

The majority of the prospective science teachers could not give any answer for the reason of the events to be unscientific (Table 6). It is interesting that while all of them put forward the phenomena to be scientific; only few claimed the events to be unscientific due to phenomena (Table 6). Rather, they claimed logical based understanding and perceived features to be the reasons of events which are unscientific. Again, as in the reasons for scientific also the reasons for unscientific are less valued on sociological based issues (Table 6). Ash (2004) states that the scientific knowledge gained through formal education corresponds to the events frequently they meet in their daily lives. Besides, they had been under a wide range of exposure to science including school science, science documentaries on television, scientific issues reported in the news, undergraduate science education and interactions with science teachers (Ryder and et al., 1999). Considering these factors, the prospective science teachers were expected to explain their ideas about distinguishing the scientific from unscientific. However, the result of this study indicates they have challenges in explaining the reasons behind unscientific issues.

The Scientific Questions

The prospective science teachers' understanding of scientific questions ranges from empirical to relational based categories (Table 7). Moreover, the differences observed among these categories are found to be significantly different (Table 7). It reveals that the prospective science teachers' understanding of scientific events differ significantly with empirical based understanding to be the most and relational based understanding is to be the least given reasons for their own examples of scientific questions. On the contrary to the reasons given for their own examples of scientific events (Table 6), almost half of the prospective science teachers' understanding of scientific questions based on their own examples address empirical issues (Table 7). This understanding is followed by phenomena based understanding (Table 7). It is also noticeable that there was a group of prospective science teachers who were not able to explain about the reasons of their questions as scientific in their examples (Table 7). The rest of the answers were shared among logical based understanding, perceived features, sociological and relational based understandings. It is interesting that the perceived feature category for the scientific questions exhibits characteristics of the traditional science same as in the meaning of being scientific (Table 2).

Palmquist & Finley (1997) claimed that the teachers' traditional understanding of science result from the traditional instruction they had. This corroborates the effect of traditional understanding on science despite the courses they have taken such as "nature of science and history of science" and "science teaching methods" in the faculty. The aims of these courses are to give basic idea of nature and history of science and to teach the ways for instructing science.

The categorization of scientific questions displays that the majority of the prospective science teachers find the questions related to bacterium, Earth, atmosphere, migratory birds, diet and the kind of the fabric to be scientific in higher turnouts (Table 8). These findings are parallel to their own examples which reveal that empirically testable and phenomenally perceivable questions are seen as

ISSN 1648–3898

scientific (Table 7). It is also consistent with the majority's phenomena based reasons they stated for the questions which are given (Table 9).

It is also noticeable that, the questions related to "having fun", "buying", "ghosts" and "best T.V. program" are seen as unscientific (Table 8). This shows that, the prospective science teachers are generally successful at differentiating the questions addressing science regarding logical argument (Harlen, 2000). The reasons for the unscientific events (Table 6) and unscientific questions (Table 9) also support this finding where almost all of the prospective science teachers put forward logical based arguments.

Furthermore, their statements including the reasons behind the scientific questions also corroborate this conclusion as only one fourth of the prospective science teachers explicitly gave reasons on logical based understanding (Table 9). It is also interesting that only few of the prospective science teachers stated explicitly that all the questions to be viewed as scientific since they all are needed to be considered critically (Table 8). However, when considering Harlen's (2000) claim that sometimes there are no critical comments to make where just recognizing the evidence of review is sufficient, this group of questions might have not raised critical thinking of the prospective students.

As seen from Table 9, more than one fourth of the prospective science teachers gave answers based on perceived features emphasizing about the knowledge required. Besides, more than one tenth of the prospective science teachers could not explain the reason why they find the event scientific (Table 9). This may exhibit that they had idea of scientific questions without knowing the reason behind. This finding may also result from the rote application of science concepts that was previously mentioned.

Interestingly, one fifth of the prospective science teachers found the questions to be unscientific depending on their content related to belief (Table 9). These answers seem parallel to the reasons given for the unscientific events except from the categories of no answer, phenomena based and sociological based understandings (Table 6). Therefore, it may be concluded that what makes an event or a question unscientific is the logical issues and perceived features.

The Scientific Knowledge

Table 10 shows that the prospective science teachers' descriptions of scientific knowledge rely on phenomena, empirical, historical and relational based understandings with no answer category. The observed difference among these categories was found to be significantly different (Table 10).

The prospective science teachers' understanding of scientific knowledge displays that they have phenomena based understanding (Table 10). It is seen that they think of "accepting on investigation" as a restriction for the scientific knowledge. In their explanations, they could not explicitly mention about the justification procedure of knowledge for accepting to be scientific. This result may indicate that a considerable amount of prospective science teachers are not able to differentiate the justification procedure for the scientific knowledge. This also needs investigation regarding how prospective science teachers perceive science and its components such as laws, theories and any processes. At the same time, they argue that scientific knowledge is proven by experiments rather than the ordinary experiences producing knowledge in empirical grounds (Table 10). Similar to this finding, Ryder and et al. (1999), in their study with the final year university students, also found that the students tended to view knowledge claims in science as provable beyond doubt using empirical data alone.

In addition, a considerable number of prospective science teachers (12%) failed to describe the scientific knowledge (Table 10). This finding is quite challenging in relation with the question to what extent the prospective science teachers get ready to teach science without having a description of the scientific knowledge in mind. Moreover, there are also prospective science teachers who see the universally accepted things (historical based, 8%) and things explained by its causes (relational based, 4%) in quite lower turnouts (Table 10). Because, science teachers need to have a true understanding of scientific knowledge both in order to realize the goals of the science education and to help students improve true understanding of scientific knowledge (Tsai, 1999, 2000).

To sum up, this study has similar findings with the studies showing that the prospective science teachers' have difficulties in articulating the science and scientific issues (Turgut, 2009; Irez, 2006; Tairab, 2000; Lederman, 1992; Aikenhead & Ryan, 1992). Since the science teachers mainly have to meet new social, pedagogic and subjective requirements (Lamanauskas, 2007), the faculties of education are seen the last station for the prospective science teachers before embarking (Abd-El-Khalick & Lederman, 2000). Therefore, this profile can be evaluated as quite challenging.

Conclusion and Implications

The scientific understanding profile of the prospective science teachers drawn by this study is not heartening. This research results revealed that, the prospective science teachers have understanding of scientific issues that mostly based upon phenomenon and empirical based understanding and perceived features those address the traditional view of science. Moreover, they seem to have inadequate understanding of science regarding logical, relational, sociological and historical aspects. It is also surprising that they tend to evaluate the events with rough and surface characteristics regarding their scientific property and their level of relating science to daily life is very low and problematic. They tend to evaluate the issues in a rote manner rather than thinking deeply or establishing further relations in mind. Besides, they have challenges in stating the reasons behind unscientific events. They find empirically testable and phenomenally perceivable questions scientific although they have difficulty in articulating the reasons. As far as they could state, what makes an event or a question unscientific is the logical issues and perceived features. On the other hand, besides the failure at defining the scientific knowledge it is also seen that the justification procedure of knowledge is not clear for the prospective science teachers and they have difficulty in differentiating the scientific knowledge from any component of science.

The reasons for this result may be grouped under three main headings and recommendations may be proposed accordingly. Firstly this result may be seen as the natural effect of the central examinations which the prospective teachers enter in before and after university. Before university, they enter Passing to Higher Education Examination (PHEE) and Undergraduate Settlement Examination (USE) which both measure the content of the courses they have taken during the high school by multiple choices tests. Both PHEE and USE affect young people focusing on solving the test through the choices avoiding them think deeply or divergently on the questions or problems in a limited test time. Therefore, they have tendency to pass these examinations and enter the university without considering the meaning of the science courses they took. After university, they enter into another central examination which is called The Civil Servant Selection Examination (CSSE) and organized by The Turkish Government to be taken into service as civil servants. This examination has questions on general ability, culture and educational sciences which do not measure the scientific understanding or teaching of science as a profession. Due to the economical problems most of the graduated or the prospective science teachers prepare for this examination in order to be taken into service starting from their early years at the faculty. Therefore, they focus on the content of this examination rather than the courses related to their profession which means they discount the issues related to science or science teaching and they do not tend to make an effort to develop themselves about scientific understanding. At that point, the ways of passing, placing the prospective science teachers to higher education and employing them after graduation should be changed. Especially, after the graduation an assessment towards teaching or understanding of science in order to grow competent science teachers having true understanding of science and science teaching should take place.

The second reason may be the science learning environments offered to the prospective science teachers. The learning environments beginning from the first year at university should be improved regarding the knowledge about both the content and the nature of science to change the general views about science. A science course based on the discussions of issues which is also trying to address the science that students meet outside the school, will make new demands on teachers and on prospective science teachers (Millar & Hunt, 2002). Therefore, the science teacher education programs need to be discussed about to what extent they are successful at growing science teachers with the true understanding of science. During the courses such as "nature and history of science" and "science teaching methods" in the faculty, the science concepts need to be extended explaining the everyday phenomena by emphasizing the social aspects of the science and scientific issues. Furthermore, the nature of scientific knowledge purposefully and explicitly should take place and the science concepts

ISSN 1648–3898

should be extended explaining the everyday phenomena during these courses (Bell et al., 1998). Therefore, the nature of science understanding of the professors at the faculty also needs to be investigated in order to determine their level and then design a program for them to enrol for improving themselves. It is believed that only through by this way it will be possible to articulate that science rises from the life and therefore is essential for the life.

The third reason may be the general perception of science by the majority of the public. As a part of the public, the prospective science teachers' understanding of science also gives a real insight into the public understanding of science. Therefore, the situation and perception of science among people should be discussed by the official and civil organisations to encourage and stimulate the scientific understanding by several activities towards scientific understanding especially to the relations of science and society.

Finally, as classroom events create and confront teachers' knowledge about science (Nott & Wellington, 1996), this research should be conducted with complementing by observation of the prospective science teachers in natural classroom settings in order to figure out their understanding of science. The findings of this research also show that besides determining the understanding of science among the prospective science teachers individually, the development and evolution of this understanding for the following years after their graduation as a means of a life-long curriculum should be examined.

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Received 21 June 2010; accepted 18 October 2010

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