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International Journal of Education in Mathematics, Science and Technology

International Journal of Education in Mathematics, Science and Technology (IJEMST)

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To cite this article:

Yenice, N. & Ozden, B. (2013). Analysis of scientific epistemological beliefs of eighth graders. *International Journal of Education in Mathematics, Science and Technology, 1*(2), 107-115.

IJEMST International Journal of Education in Mathematics, Science and Technology

Volume 1, Number 2, April 2013, 107-115 ISSN: 2147-611X

Analysis of Scientific Epistemological Beliefs of Eighth Graders

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Abstract

The aim of this study is to determine the levels of scientific epistemological beliefs of 8th grade students. The sample of the study consisted of 355 students. The data of the study were collected through the use of the Scale of Scientific Epistemological Beliefs, which was developed by Elder (1999) and adapted into Turkish by Acat, Tuken and Karadag (2010). Personal Data Form was also used to obtain demographic data about the participants. In order to determine the levels of scientific epistemological beliefs of the students, the means and standard deviations were calculated for each scale. The findings of the study suggest that scientific epistemological beliefs of 8th grade school students are closer to sophisticated beliefs and mid-level.

Key words: Scientific Epistemological Beliefs, Science Education, Elementary Students.

Introduction

Today the students with the following qualities are needed: search for, question, analyze, develop relationships between daily life and science topics, use scientific method to solve daily problems, look at the world using a scientific approach, use and comprehend the basic science concepts, principles and theories (MNE, 2006). Therefore, the course, science and technology, is very significant in this regard.

In recent years, different approaches towards scientific thinking and scientific knowledge have affected the educational programs, leading to the development of new standards concerning science and scientific knowledge and the characteristics of scientists (AAAS 1993, NRC 1996). Such effects also exist in Turkey. For instance, revised program of the course, science and technology, in 2004 emphasizes science literacy and uses constructivist approach to teaching as its basis (Tüken, 2010). Therefore, one of the major objectives of science education is stated to produce students with science literacy.

Current program of the course, science and technology, defines science and technology literate persons as follows (MNE, 2006): “Science and technology literates are those who are competent in accessing and using knowledge, solving problems, making decisions over problems about science and technology taking into consideration the potential risks, uses and available options and producing new information.”

Ayvacı and Nas (2010) argue that science and technology literate people can effectively use scientific concepts and have information about the nature of scientific knowledge. Furthermore, they are informed about the qualities of scientific knowledge.

Comprehending the nature of science and scientific knowledge is one of the significant characteristics of science and technology literacy. The term the nature of science has been defined in various ways. For instance, Lederman (1992) defines it as the values and assumptions in the nature of science. Kıray (2010), on the other hand, analyses the nature of science under four headings as follows:

- *Source of the scientific knowledge:* Many scholars and philosophers developed various views concerning the source of scientific knowledge (Kıray, 2010). Scientific knowledge has been produced through observations and inferences, but imagine and creativity also played a role in this production. Scientific knowledge “is produced partly by imagination and inferences.” (Lederman, 1999). It is also

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reported that socio-cultural environment also affect the scientific knowledge (Akerson, Abd-El-Khalick & Lederman, 1999).

- *Degree of accuracy in the scientific knowledge:* In regard to degree of accuracy of the scientific knowledge, various views were offered (Kıray, 2010). The commonest approach to the scientific knowledge is that scientific knowledge is not the one that is absolute. Because the scientific knowledge is subject to modification through observations. The new findings and socio-cultural characteristics may also lead to changes in the scientific knowledge (Lederman, Abd-El-Khalick, Bell and Schwartz, 2002). Therefore, although the scientific knowledge is reliable and can remain valid for a long period of time, it is not absolute truth and certain.
- *Advances in the scientific knowledge:* There are main approaches to the development in the scientific knowledge; evolutionary and revolutionary. Evolutionary approach suggests that each new knowledge is based on the previous ones. The latter approach, on the other hand, argues that each new knowledge is produced bu falsifying the previous ones. Therefore, the philosophy of science that one adopts determines which approach is followed. For those who follow the positivist science philosophy, scientific knowledge develops through verification and is based on the previous knowledge. Kuhn, on the other hand, suggests that advances in science would occur through revolutions (Kuhn, 1957). On the contrary, Lakatos argues that science advances through evolutions. Science can be stated to be open to both revolutions and evolutions (Kıray, 2010).
- *Consistency and validity of the scientific knowledge:* In order to show the consistency and validity of the scientific knowledge, there are many ways. For instance, verification, documentation, testing, description, definition and falsifying are all used to show that the scientific knowledge is consistent and valid (Sönmez, 2008). Scientific theories are well-organized and well-backed accounts of a phenomenon. Scientific laws, on the other hand, are the descriptions of the relations observed between the events or phenomena observed. For instance, Boyle law (1670) describes the relationship between gas pressure and volume, the theory of kinetic molecular (1850) provides the reasons for this relationship. Both theories and laws are subject to modification (Irez and Turgut, 2008). Therefore, although both laws and theories are supported by good evidences, their validity is limited.

Studies on the nature of the scientific knowledge and science mostly include the scholars philopsophy of science that ranges from positivist/realist/traditionalist to post-positivist/postmodern (Deryakulu and Bıkmaz, 2003; Kaplan, 2006; Meral and Çolak, 2009; Terzi, 2005; Tsai, 1998; Turgut, 2009; cited in Tüken, 2010).

Constructivist approach that was resulted from the post-positivist philosophy of science states that knowledge is not an independent entity, out of individuals; instead, it is context-based and individual (Yurdakul, 2005). The constructivist approach emphasized the questions of what is knowledge? and how it is produced? As a reflection of this approach, the scientific knowledge is also expressed through other terms such as "epistemological view" and "epistemological belief" (Çoban and Ergin, 2008).

Scientific epistemological beliefs involve the individual philosophy over reliable and valid scientific knowledge, their production and share (Deryakulu and Bıkmaz, 2003). Students' epistemological beliefs govern their attempts to understand the production and evaluation of the scientific knowledge, to learn the scientific concepts and to understand the nature of science (Elder, 1999; Tsai, 1998, 1999, 2000). There are various scales used to describe the students' epistemological beliefs. For instance, Schommer (1990) developed the scale of multi-dimensional epistemological beliefs and suggested five dimensions of epistemological beliefs. Dimensions included in the scale are as follows: i) Inborn ability, (ii) rapid learning, (iii) simple knowledge and (iv) absolute knowledge. The dimension of inborn ability states that the ability to learn is fixed. The second dimension, rapid learning, includes the fact that either learning takes place in a short period of time or it does not occur. The next dimension, simple knowledge, involves the belief that knowledge is consisted of both independent parts and interrelated concepts. The dimension of absolute knowledge is composed of the belief that knowledge is absolute (Schommer, 1990). Çoban and Ergin (2008) also developed a scale concerning epistemological beliefs with a sample of 505 students. This scale includes 16 items under three dimensions as follows: (i) Scientific knowledge is closed, (ii) scientific knowledge is justifiable and (iii) scientific knowledge can be modified.

In recent years, studies in which students' epistemological beliefs are analysed in relation to certain variables become common. The epistemological beliefs of the students were analysed in relation to the following variables: academic achievement (Schommer, 1990, 1993; Tolhurts, 2007), age (Schommer, 1998), the strategy used (Cano, 2005; Chan, 2003; Holschuh, 1998; Tsai, 1998), culture (Chan & Elliott, 2002; Youn, 2000), and gender and socio-economic status (Özkal, Tekkaya, Sungur, Çakıroğlu & Çakıroğlu, 2011). In Turkey, the epistemological beliefs of undergraduate students and student teachers are analysed in various studies (For instance, Akpınar, Dönder & Tan, 2010; Ayvacı & Nas, 2011; Eroğlu & Güven, 2006; Gürol, Altunbaş &

Karaaslan, 2010; Kaplan, 2006; Kaygın, Baş, Kanbolat & İneç, 2010; Kaynar, Tekkaya & Çakıroğlu, 2009; Kızılgüneş, Tekkaya & Sungur, 2009; Meral & Çolak, 2009; Özşaker, Canpolat & Yıldız, 2011; Terzi, 2005). On the other hand, a few studies have been carried out to analyse the epistemological beliefs of basic education students in relation to certain variables (Boz, Aydemir & Aydemir, 2011; Kurt, 2009; Özkal et. al., 2011; Topçu & Yılmaz-Tüzün, 2009; Tüken, 2010; Yenice, 2010). For instance, Boz, Aydemir & Aydemir (2011) identified the epistemological beliefs of the fourth, sixth and eighth graders and concluded that their epistemological beliefs significantly vary based on grade level and gender. Tüken, (2010) determined the epistemological beliefs of rural and urban eighth grade students and found that the epistemological beliefs of the students significantly differ based on certain variables

It is thought that in order to reach the objectives set by the Ministry of National Education (2006), students should comprehend the nature of the scientific knowledge, its limitations and the production. Therefore, analysis of the students' epistemological beliefs regarding science education is significant. Thus, the aim of this study is to identify the level of eighth grade students' epistemological beliefs.

Statement of problem

Statement the research problem was defined "What is the level of eighth grade students' epistemological beliefs?

Method

Model and participants of the study

The study has a descriptive design and uses the scanning model. The participants of the study are randomly selected eight-grade students attending public basic schools in Nazilli district of Aydın province during the school year of 2011–2012. The number of the participants is 355, 170 males (47.9 %) and 185 females (52.1 %).

Data collection tools

In order to determine the level of the students' epistemological beliefs, the "Scale of Scientific Epistemological Beliefs", which was developed by Elder (1999) and adapted into Turkish by Acat, Tüken and Karadağ (2010), was used. Demographical form was also used to obtain information concerning the demographical characteristics of the participants. The epistemological beliefs scale includes 25 items in the form of likert-type. It is consisted of five sub-dimensions of authority and accuracy, the process of knowledge production, the source of knowledge, reasoning and the changeability of knowledge. The Cronbach Alpha reliability coefficient of the scale was found to be 0.82. Its reliability was analyzed again before its use in this current study and found to be 0.75.

Analysis of data

Means (X) and standard deviations of the student scores in the subdimensions were calculated. The beliefs of the students are labelled under three headings as follows: traditional (underdeveloped) beliefs for those with the score from 1.0 to 2.5; mixed (medium level) beliefs for those with the score from 2.6 to 3.5 and developed (contemporary) beliefs for those with the score from 3.6 to 5.0. For the subdimensions of authority and accuracy, and the source of the knowledge, higher means refer to traditional beliefs (Tüken, 2010).

Findings

The answers of the students to each item in the subdimensions of the scale were analyzed. Table 1 provides the mean scores and standard deviations in regard to the items included in the subdimension of *Authority and Accuracy.*

Table 1. Mean scores and standard deviations in regard to the items included in the subdimension of Authority and Accuracy

Subdimension	Items	N	Mean	SD
Authority and Accuracy	1. In science, all questions have only one correct answer.	355	3.20	1.40
	5. Scientists know almost everything about science, so there is nothing new to be known.	355	2.08	1.32
	12. Whatever teachers say in the courses are right.	355	2.63	1.26
	15. The findings of an experiment are the sole truth about the phenomenon at hand.	355	2.74	1.28
	16. Everybody should believe in what scientists says.	355	2.14	1.23
	20. Only scientists know the truth in science.	355	2.45	1.33
	23. Scientists have the same ideas about the truth in science.	355	2.44	1.27
	24. Scientists never say "maybe", because they always know the truth.	355	2.49	1.31
	25. Teachers and scientists always express scientific views.	355	2.27	1.35
	Means and standard deviation of the scores	355	2.49	.86

As seen in the Table, mean score of the students in the subdimension of *Authority and Accuracy* is 2.49. Therefore, the students' beliefs in regard to this subdimension are developed. On the other hand, the students have traditional beliefs about the following item in this subdimension: "In science, all questions have only one correct answer."

Table 2 provides the mean scores and standard deviations in regard to the items included in the subdimension of *the process of knowledge production*.

Table 2. Mean scores and standard deviations in regard to the items included in the subdimension of the process of knowledge production

Subdimension	Items	N	Mean	SD
Process of Knowledge Production	3. The most significant role of scientific study is to reveal the truth.	355	1.87	1.05
	4. The most important role of science is to carry out experiments to obtain new ideas about the functioning of the universe or objects.	355	4.13	.89
	7. If scientists work hard, they can answer all questions.	355	2.07	1.09
	8. More than one experiment should be done to be sure about the discovery.	355	4.47	.78
	11. Experiments are good ways to know whether or not anything is true.	355	4.23	.95
	18. Correct answers are based on the findings obtained from many experiments.	355	4.21	.95
	Means and standard deviation	355	3.50	.38

Table 2 shows that the mean score of the students in the second subdimension, the process of knowledge production, is 3.50., however, the third and seventh items in this subdimension are reversely coded. The mean scores for these items are 1.87 and 2.07, respectively. Therefore, the students appear to have traditional or underdeveloped beliefs. However, regard to other items, it can be argued that the students have developed beliefs.

Table 3 provides the mean scores and standard deviations in regard to the items included in the subdimension of *the source of knowledge*.

As seen Table 3, the mean score of the students in the subdimension of the source of the knowledge is 2.97. therefore, they have mixed beliefs in regard to this subdimension. However, in regard to the item, "We should be sure about what we read in the scientific books.", the students appear to have traditional belief.

Table 3. Mean scores and standard deviations in regard to the items included in the subdimension of the source of knowledge

Subdimension	items	N	Mean	SD
Source of Knowledge	6. Scientific knowledge is always correct.	355	3.23	1.20
	10. We have to believe in what we read in the scientific books.	355	2.41	1.21
	13. We should be sure about what we read in the scientific books.	355	3.25	1.12
	14. We should believe in what our teacher say about science, although we cannot fully understand.	355	3.00	1.29
	Mean and standard deviation	355	2.97	.87

Table 4 provides the mean scores and standard deviations in regard to the items included in the subdimension of *reasoning*.

Table 4. Mean scores and standard deviations in regard to the items included in the subdimension of reasoning

Subdimension	Items	N	Mean	SD
Reasoning	2. The views about experiments are resulted from curiosity and thinking about events and facts.	355	4.36	.74
	21. Before doing an experiment, one should be informed about it.	355	4.51	.82
	22. Curiosity over the reasons for events and facts is the best way to be informed about a scientific phenomenon.	355	4.30	.90
	Mean score and standard deviation	355	4.39	.60

The mean score of the students at the subdimension of *reasoning* is 4.39. Therefore, their beliefs in relation to this subdimension are developed.

Table 5 provides the mean scores and standard deviations in regard to the items included in the subdimension of *the changeability of knowledge*.

Table 5. Mean scores and standard deviations in regard to the items included in the subdimension of the changeability of knowledge

Subdimension	Items	N	Mean	SD
Changeability of Knowledge	9. In science, views sometimes change.	355	3.98	.99
	17. New discoveries lead to changes in the views of scientists about truth in science.	355	4.14	.97
	19. Scientists change their views about the truth in science.	355	3.89	.95
	Mean score and standard deviation	355	4.00	.69

The mean score of the students at the subdimension of changeability of the knowledge is 4.00, suggesting that the students have higher than mixed beliefs.

Discussion and Conclusion

The findings of the study indicate that the students participated in the study have developed epistemological beliefs in relation to three subdimensions; *Authority and Accuracy, Reasoning and Changeability of the Knowledge*. However, it is also found that their beliefs are underdeveloped in regard to the remaining two subdimensions; *the Source of the Knowledge and the Process of the Knowledge Production*.

At the subdimension of *Authority and Accuracy*, there are beliefs about science and the source of the scientific knowledge, absoluteness of the knowledge and outside sources of it. As stated above, the students participated in the study have developed epistemological beliefs in this regard. Therefore, they believe that science has a nature that is evolving and that scientific knowledge is based on authority. However, they are also found to believe that there is only one correct answer. Their belief in single correct answer is certainly traditional. Songer and Linn (1991) argue that students compare the findings of different scientists and believe that scientists working on the same experiment may reach different conclusions and that scientist makes use of evidence to solve the disputes. In the current study, it is also found that students have developed beliefs in regard to the fact that scientists may not always reach the correct answer and that they cannot agree on a single truth. Furthermore, the level of the students' belief is mixed regarding the fact that the findings of an experiment are the single truth about the phenomenon at hand. Therefore, it is safe to argue that students do not have developed understanding of science. Tüken (2010) found that students have generally mixed beliefs in regard to the subdimension of *Authority and Accuracy*. It was also found that students believe in single correct answer, the evolving nature of science and the correctness of the findings obtained from experiments. Therefore, these findings support those of the current study.

The subdimension of *the Process of the Knowledge Production* includes the methodological characteristics of science. The students are found to have mixed beliefs in regard to this subdimension. Mean scores of the students at this subdimension suggest that they understand the empirical quality of science. However, students also believe that more than one experiment is needed to reach the correct answer. Therefore, it can be argued that the students' related epistemological beliefs are developed. In parallel to this finding, Carey, Evans, Honda, Jay and Unger (1989) found that majority of the seventh grade students understand the fact that scientific research is directed with certain views and thoughts and that experiment refer to testing of these views. Muşlu (2008) found that students attach importance to experiments and observations. Tüken (2010) also found that the beliefs of the students at the subdimension of *the Process of the Knowledge Production* are mixed and that they attach significance to experiments. Therefore, the present finding is consistent with that of Tüken's study. However, in regard to two items in this subdimension students are found to have traditional beliefs. The students appear to focus on the results of the experiments and correct answers. Therefore, it can be argued that they do not have well developed beliefs about the nature of science. The reason for this may be in-class practices of teachers. Tsai (2003) argues that those teachers with positivist approach to science regard experiments as a way to verify the scientific knowledge.

The beliefs of the students at the subdimension of *the source of the knowledge* are between traditional and developed. They are found to view books and teachers as the source of knowledge and to believe that scientific knowledge is always correct. It is further found that students accept what they read in the books as correct knowledge. There are previous findings that are consistent with this finding (Roth and Roychoudhury, 1993; Saunders, 1998; Tüken, 2010; Boz et. al., 2011; Savaş, 2011). Saunders (1998) found that students strongly believe in that knowledge taken from outside sources and that they have mixed epistemological beliefs. Tüken (2010) found that students have generally mixed beliefs in regard to this subdimension and that students mostly believe the correctness of the scientific knowledge. Similarly, Boz et. al. (2011) concluded in the study with a sample of the fourth, sixth and eighth grade students that they have underdeveloped epistemological beliefs regarding the certainty and source of the scientific knowledge. However, Lehrer, Schauble and Lucas (2008) suggest that in a classroom environment in which students are active participants of the learning process, students focus on their own activities. Therefore, it can be stated that if students are made active participants of the learning process, they will less regard teachers as an authority.

At the subdimension of reasoning in which curiosity and prior knowledge are emphasized, the students are found to have developed beliefs. Students believe that curiosity leads to be informed about scientific phenomenon and prior knowledge is needed to make experiments. Therefore, the student beliefs at this subdimension are developed. Some other findings support this finding of the study (Smith, Maclin, Houghton and Hennessey, 2000; Tsai, 2000; Tüken, 2010). Tüken (2010) also found that the student beliefs regarding this dimension are generally developed.

In regard to the subdimension of *the changeability of the knowledge*, the students are also found to have developed beliefs. In other words, students believe that the views of scientists may change and that new discovery and inventions lead to changes in the views about the truth in science. Therefore, students seem to have those beliefs very close to scientific approach. This finding is supported by the findings of some previous studies (Muşlu, 2008; Kurt, 2009; Tüken, 2010; Savaş, 2011). Muşlu (2008) also found that students believe that the views of scientists may change. Similarly, Tüken (2010) also concluded that student beliefs at this subdimension are developed. This finding is also consistent with that of Smith, Maclin, Houghton and Hennessey (2000) in that the students in constructivist classroom settings are aware of the changeability of scientific views.

In conclusion, the scientific epistemological beliefs of the eighth grade students participated in the study are either mixed or developed. On the other hand, classroom activities can be developed to reduce the student beliefs regarding the fact that the scientific knowledge is always correct. Additionally, since students seen to focus on the results of the scientific research, necessary classroom activities can be employed to show them that methodology is also an important part of scientific endeavor. The sample of the study included the eighth grade students and their epistemological beliefs were quantitatively analyzed. Therefore, the epistemological beliefs of other students at different educational levels can be analyzed, following a qualitative research.

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