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Elementary Students' Scientific Epistemological Beliefs in Relation to Socio-Economic Status and Gender

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Abstract This study investigated students' scientific epistemological beliefs in relation to socio-economic status (SES) and gender. Data were obtained from 1,152 eight grade Turkish elementary school students using Scientific Epistemological Beliefs instrument. Canonical correlation analysis indicated that students with a working mother and educated parents as well as greater number of books at home together with a separate study room are more likely to have tentative views and less likely to have fixed views about science compared to students with unemployed mother, uneducated parents, less books at home, and no separate study room. Generally, results revealed while family SES correlated positively with tentative views, it was negatively associated with fixed views, implying that students from high SES family were more likely to believe that knowledge is uncertain and not handed down by authority compared to students from low SES family. This study, however, failed to indicate any relationship between father work-status, buying daily newspaper and epistemological beliefs. In addition, Multivariate Analysis of Variance indicated that boys more likely to have tentative beliefs compared to girls.

Keywords Epistemological beliefs · Socio-economic status · Gender

Introduction

Recent reforms in science education stress the importance of the development of students' adequate understandings of the nature of science or appropriate epistemological views of science. Nature of science (NOS) has been defined as the values and assumptions inherent to the development of scientific knowledge, and the distinction

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between science and non-science (Lederman 1992). Understanding of NOS has been claimed to be an important component of scientific literacy which is characterized as appreciation of empirical evidence and subjectivity of the scientists in the development of scientific knowledge, tentativeness of scientific knowledge, appreciation of creativity, having a partial role on development of scientific knowledge, socially and culturally embeddness of scientific knowledge, beside the recognition of the difference between observation and difference and function of theories and laws (Abd-El-Khalick and Lederman 2000; Lederman et al. 2002).

In accordance with the reform movements in science curricula all around the world, recent science education reform in Turkey also has focused on the importance of the nature of science and technology and their interdependence with the society. The vision of the new science and technology curriculum is that ''all students, regardless of individual and cultural differences, should develop scientific and technological literacy'' (MONE 2005, p 5). The goal of the science and technology course is, therefore, to promote the development of scientifically and technologically literate citizens, who are capable of (a) utilizing science process skills and scientific concepts in solving everyday problems and making decisions, (b) comprehending the nature of science and technology, (c) critically analyzing the newly generated scientific knowledge and its role in human society, (d) identifying the strengths and the limitations of science and technology for advancing human goodness, (e) analyzing the interactions among science, technology, and society, (f) making meaningful connections of science and technology to other human endeavours, and (g) developing values and attitude toward science (MONE 2005).

Although NOS is highlighted in science education reform effort as a fundamental component of science education programs, research has consistently shown that students from various age groups have not attained the desired understandings of NOS or scientific epistemologies (Abd-El-Khalick and Lederman 2000; Lederman 2007). The research suggests that students' epistemological views of science influence the students' thinking, reasoning, and understanding of science (Elder 1999; Lederman 1992; Tsai 1998, 1999, 2000). It is clear that scientific epistemological beliefs appear to be an important indicator for science educators to predict students' learning and to prepare science instruction. Thus, understanding these beliefs may provide valuable insight how to improve students' thinking and learning in science. Accordingly, researchers started to determine students' existing scientific epistemological beliefs and proposed several models to explain such beliefs. For example, Schommer (1990) conceived of epistemological beliefs as multidimensional. She initially suggested five different epistemological dimensions which are omniscient authority (knowledge is handed dawn by authority rather than derived from reason), quick knowledge (learning occurs in a short amount of time or not at all), certain knowledge (knowledge is unchanging), simple knowledge (knowledge is isolated facts), innate ability (the ability to learn is fixed at birth) (Schommer 1990). Conducting a series of studies with college students, she developed and validated a questionnaire assessing students' epistemological beliefs in four dimensions, namely, simple knowledge, certain knowledge, innate ability, and quick learning. Her later studies revealed that high school students also possessed these four epistemological belief factors (e.g., Schommer 1993; Schommer et al. 1992).

In recent years, there has been an increasing interest in the area of educational psychology in assessing students' epistemological beliefs in relation to certain variables. Among them are academic achievement (Schommer 1990, 1993; Tolhurts 2007), age (Schommer 1998), strategy use (Cano 2005; Chan 2003; Holschuh 1998; Tsai 1998), field of study (Trautwein and Lüdtke 2007) culture (Chan and Elliott 2002; Youn 2000), motivation (Buehl 2003; Murphy et al. 2002; Paulsen and Feldman 1999, 2005; Ravindran et al. 2005) and perception of classroom learning environments (Tsai 2000) as well as socio-economic status, and gender. In an early work, Schommer (1990) examined student characteristics and home background variables that predict epistemological beliefs. Information regarding gender, age, year in school, parents' education, number of courses completed were collected. The finding indicated that students' epistemological beliefs were predicted by these background variables. For example, the number of classes that students had complicated in higher education was found to be important determinant influencing students' beliefs about nature of knowledge. Students who completed more classes in high school were more likely to believe in the tentative nature of knowledge. Also parents' level of education and parents' expectation of their children to take responsibilities in the home and for their own thinking were found to be significantly related to students' beliefs about simplicity of knowledge and speed of knowledge gaining. That is, children of educated parents providing them with opportunity for independence are more likely to develop a sophisticated system of epistemological beliefs. None of the variables, however, were found to be associated with the belief that tentative nature of knowledge. Recently, Trautwein and Lüdtke (2007) conducted to a large-scale longitudinal study to explore the relationship of beliefs in certainty of knowledge with school achievement and future field of study. In their study, certainty beliefs correlated significantly and negatively with SES, cultural capital, final school grade, and cognitive abilities. No statistically significant relation, however, was reported between certainty beliefs, gender and age. Contrary to these findings, however, in their investigation of the relationships between epistemological beliefs, parents' social status and school preferences, Brabander and Rozendaal (2007) suggested that although epistemological beliefs were correlated with the level of education, it is not related to status level and status type.

Apart from, Elder (1999) highlighted that elementary grade students hold beliefs about the nature of scientific knowledge as well. Elder examined the relationship between epistemological beliefs and science learning by using 5th grade students. She mentioned that elementary-aged students rely on constructs like the changing nature of knowledge and the purpose of science while trying to comprehend a larger field of epistemological beliefs and may initially come to understand the nature of scientific knowledge in a very situated, topic-dependent manner. In her study, Elder (1999) also proposed that girls compared to boys, may tend to support dependent sources and have less sophisticated beliefs, that higher SES may be related to more sophisticated beliefs about coherence of scientific knowledge. She reported no differences in students' beliefs regarding definition of science, role of authority, experimenting and reasoning, the source, and the tentative nature of science. In another study, Conley et al. (2004) examined the change in 5th-grade students' epistemological belief over the course of instruction based on hands-on science and

the role gender, ethnicity, SES, and achievement play in this development. Their results indicated that over time students became more sophisticated in their belief about source and certainty of knowledge. No changes were reported, however, in justification and development of knowledge. While main effects of SES and achievement were reported, no effects for gender or ethnicity were indicated. Compared to average SES and high achieving students low SES and low achieving students found to have less sophisticated belief about knowledge. Average SES students were reported to held higher scores on certainty, source, justification, and development than low SES students.

Concerning the role of gender in epistemological beliefs, some studies indicate that there are no differences between girls and boys in terms of their epistemological beliefs (Buehl et al. 2002; Chan and Elliott 2002; Conley et al. 2004; Schommer 1993), other studies identify differences in students' beliefs by gender (Bendixen et al. 1998; Neber and Schommer 2002; Schommer and Dunnell 1994). For example, Bendixen et al. (1998) found that among certain knowledge, innate ability, quick learning, simple knowledge and omniscient authority, certain knowledge was the only belief that makes difference between boys and girls; boys, compared to girls, tended to believe that knowledge is certain and unchanging. In addition, a series of study conducted by Schommer and her colleagues reported significant effects of gender on two of the four epistemological factors. Particularly, girls were found to be less likely to believe in quick learning and fixed ability compared to boys (Schommer 1993; Schommer and Dunnell 1994; Schommer et al. 1997). Gender-related differences in epistemological beliefs were also explored in another study which revealed that boys have stronger belief in quick learning than did girls (Neber and Schommer 2002). In her work with undergraduate students, Hofer (2000) demonstrated significant univariate but not multivariate effect of gender for certainty and source of knowledge. Boys compared with girls expressed greater beliefs about certainty of knowledge and view authority as the source of knowledge. In Conley et al.'s (2004) study, however, boys and girls were not found to be differing with respect to source, certainty, development, and justification of knowledge.

Based on the cited work, it appears that the results of the studies examining epistemological beliefs in relation to specific learner characteristics revealed a mixed pattern. That is, in some investigations gender and socio-economic variables were shown to be related with students' epistemological beliefs, whereas in others no such relation was found. Although how epistemological beliefs held by students are related to cognitive processes have been an area of interest to researchers in many countries, there has been limited studies on the role of gender and home environment differences in students' epistemological beliefs. Given the focus of earlier studies and the lack of related information, inquiry into the area of relationship among young students' epistemological beliefs, family SES and gender is warranted. The main aim of the current study, therefore, is to address this gap and to investigate elementary students' scientific epistemological beliefs in relation to SES and gender.

In this study, we sought to examine the following research questions:

1. What is the relationship between SES and elementary students' scientific epistemological beliefs?

2. Is there a gender difference with respect to elementary students' scientific epistemological beliefs?

Method

Participants

The data for the current study were obtained from 1,152 eight grade elementary school students (46.1% girls, 53.9% boys) with a mean age of 14 years attending public elementary schools from one large district of Ankara, the capital of Turkey. On the basis of their school assessment, participants' grade point average in science course during the previous semester was moderate with an overall mean of 3.03 (SD = 1.38) over 5.

Cluster random sampling integrated with convenience sampling was used to obtain the sample. The district from which the sample of the study was chosen, were selected by convenience sampling method due to constrain regarding travel, time and cost. Schools which were considered as clusters were randomly selected from the district.

Measure

Scientific Epistemological Beliefs (SEB) questionnaire is a 16-item 4 point Likert instrument developed by Saunders (1998) from the existing questionnaires (Rubba, 1977; Ryan and Aikenhead 1992). It assesses the epistemological beliefs of the students with two dimensions as fixed (8 items) and tentative (8 items) views. For this study, Cronbach alpha reliability was calculated as .80. Two constructs, thus, were examined in the current study; fixed views and tentative views. Fixed views represents a belief that science is fixed, uncertain, and authoritatively known; tentative views, on the other hand, represents a belief that science is dynamic, changing, and tentatively known (Ryan and Aikenhead 1992). More specifically, for the purpose of this study, epistemological beliefs can be defined as beliefs about the nature of knowing (i.e. beliefs about the source of knowledge and the justification for knowing) and the nature of knowledge (i.e. beliefs about the certainty of knowledge and simplicity of knowledge) (Hofer and Pintrich 1997). According to Hofer and Pintrich (1997, pp 119–120), while beliefs about nature of knowing involves beliefs about evaluation of evidence, the role of authority, and the process of justification, beliefs about the nature of knowledge is seen as a progressive understanding that ranges from the view of knowledge as absolute to a relativistic view and then to a contextual, constructivist stance. According to Hofer and Pintrich, beliefs about source of knowledge range from the conviction that knowledge rely on outside the self and in external authority from whom it may be transmitted, to beliefs about the self as an active constructor of meaning. Justification for knowing, however, concerns how individuals evaluate knowledge claims, including the use of evidence, the use they make of authority and expertise, and their evaluation of experts. Beliefs about the certainty of knowledge are

concerned with the extent to which one sees knowledge as fixed or tentative, evolving and contextual. Simplicity of knowledge was conceptualized as continuum form the belief that knowledge is isolated, unambiguous bits to the belief that knowledge is highly interrelated concepts. The lower level view of knowledge is seen as discrete, concrete, and knowable facts, while at higher levels individuals see knowledge as relative, contingent, and contextual (Hofer and Pintrich 1997, pp. 119–120).

Besides, there were 11 items, referring to personal information such as age, science grade, gender, number of sibling, students' fathers' educational level (FEL), mothers' educational level (MEL), fathers' work status (FWS), mothers' work status (MWS), the number of books at home, presence of a study room, and frequency of buying newspapers.

The instrument was administered to the participants after getting permission from the administration. The first author collected the data from 1,152 eighth grade students by visiting the schools in 2 weeks. It took approximately 25-min for the students to complete the survey. All the necessary explanations were done and the directions were made clear by the researcher before the students completed the instrument. Participants were assured that any data collected from them would be held in confidence. The researcher was in the classes during the administration of the survey and no specific problems were encountered.

Results

Characteristics of Sample

Information regarding the parents' educational level, parents' occupation/working status, number of sibling, the number of books in the students' homes, amount of reading material in the home, study room, and frequency of buying newspapers as indicators of socio-economic status. As understood from the student responses, the majority of parents graduated from high school and lower. About 39% of the fathers and 29% of the mothers have university degree. The minority of parents (less than 10%) had completed a university degree. Parents' employment status data, on the other hand, reveals that while mothers are mostly unemployed (53.6%), majority of fathers (87.9%) are employed. About 36.1% of the participants had working/employed mother.

A large majority of the students (90.3%) had a room of their own to study. About one-fourth (24.7%) of students had more than 200 books in their home, and about one-fifth (22.5%) of students had books ranging from 101 to 200, 34.5% had 26–100 books, 14% had 11–25 books and only 4.5% of students had less than 10 books. Slightly more than half of the students (53.5%) reported that they had only 1 sibling, 22.2% had 2 siblings, and 8.6% had 3 siblings and only 12.5% of students did not have sibling in their home. Less than 2% had more than 4 siblings. More than half of the students (55.5%) indicated that they were always able to find daily newspaper at home. Only 2.7% reported that they never buy newspapers.

Relationship between SES and Epistemological Beliefs

In order to investigate the relationship between family SES and epistemological beliefs (fixed and tentative) canonical correlation analysis was conducted. The first canonical correlation was .14 (2% overlapping variance), accounting for the significant relationships between the two sets of variables (see Table 1).

Data on the first canonical variate were presented in Table 3. As shown in the table, with a cut off correlation of .30 (Tabachnick and Fidell 1996), all the variables in the family SES set except father work status and having daily newspaper were correlated with the first canonical variate. The first canonical variate was positively associated with all these variables but number of children and father work status. Concerning epistemological belief variables only tentative view was positively correlated with the first canonical variate. Moreover, the first pair of canonical variates indicated that while mother work status, father and mother educational level, number of books at home, availability of a study room were all positively related with tentative views, they were negatively related with fixed views. These results revealed that students having a working mother and educated parents as well as greater number of books at home and separate study room are more likely to develop tentative views about science and less likely to hold fixed views. On the other hand, a negative association was found between number of children at home and tentative views. Accordingly, it appeared that students having fewer siblings are more likely to develop tentative view. However, as the number of children increases, students tend to hold fixed view.

Table 1 Correlations, standardized canonical coefficients, canonical correlations, percents of variance, and redundancies between SES variables and epistemological beliefs variables

	First canonical variate	
	Correlation	Coefficient
SES variables		
Number of sibling	−.66	−.54
Father's occupation	−.08	−.28
Mother's occupation	.40	.2
Father educational level	.67	.27
Mother educational level	.50	−.31
Number of books	.68	.50
Study room	.38	.13
Newspapers	.21	−.10
Percent of variance	.24	
Redundancy	.01	
Epistemological beliefs variables		
Fix beliefs	−.36	−.56
Tentative beliefs	.84	.95
Percent of variance	.79	
Redundancy	.01	
Canonical correlation	.14	

In general, results revealed that while there is a positive association between family SES and tentative views, a negative relationship exists between family SES and fixed views. However, no relationship is found between father work-status, buying daily newspaper and epistemological beliefs. Moreover, the percent of variance values indicated that the first canonical variate pair extracts 24% of variance from SES variables and 79% of variance from the epistemological beliefs variables. Also, redundancy values revealed that the first epistemological beliefs variate accounts for 1% of the variance in SES variables. Similarly, the first SES variate accounts for 1% of the variance in the epistemological beliefs variables.

Effect of Gender on Epistemological Beliefs

Multivariate Analysis of Variance (MANOVA) was conducted to determine whether boys and girls differ with respect to epistemological beliefs. Results showed a statistically significant difference between boys and girls concerning the combined dependent variables (fixed and tentative beliefs), Wilk's $\lambda = .99$, $F(2,1149) = 7.68$, $p < .001$. The multivariate η^2 based on Wilk's lambda was small, .01.

Analysis of Variances (ANOVA) was carried out as follow-up tests to find out on which dependent variable boys and girls differ. Findings revealed that the ANOVA on the tentative beliefs was significant, $F(1,1150) = 13.54$, $p < .001$, $\eta^2 = .01$, while the ANOVA on the fixed beliefs was nonsignificant, $F(1,1150) = .29$, $p = .59$ (see Table 2). Specifically, examination of the mean scores displayed in Table 3 revealed that boys ($M = 23.88$, SD = 3.37) are more likely to have tentative beliefs compared to girls ($M = 23.09$, SD = 3.81). However, the effect size was quite small.

Discussion

The present study investigated the elementary students' scientific epistemological beliefs in relation to SES and gender. Findings suggested that students who had a working mother and educated parents as well as greater number of books at home together with a separate study room are more likely to hold tentative views and less likely to hold fixed views about science compared to students having unemployed mother, uneducated parents, less books at home, and no separate study room. Finding a negative relationship between number of sibling at home and tentative views, however, may imply that students having fewer siblings are more likely to

Table 2 MANOVA follow-up pairwise comparisons

Source	Dependent variable	*df*	*F*	*p*	η^2
Gender	Fix beliefs	1	.29	.591	.00
	Tentative beliefs	1	13.54	.000	.01
Error		1,150			

Table 3 Descriptive statistics

	Gender			
	Boys		Girls	
	M	SD	*M*	SD
Fixed beliefs	21.19	3.43	21.30	3.57
Tentative beliefs	23.88	3.37	23.09	3.81

develop tentative view. In general, results revealed that while there is a positive association between family SES and tentative views, a negative relationship exists between family SES and fixed views. Therefore, it appeared that students from higher SES families were more likely to believe that knowledge is uncertain and not handed down by authority compared to students from lower SES family. This study, however, failed to indicate any relationship between father work-status, buying daily newspaper and epistemological beliefs. This means that neither fathers work-status, nor buying daily newspaper influence students' beliefs about knowledge and knowing. Based on the findings, we suggest that there is a need in science education for a special emphasis on students with lower socio-economic status to improve their scientific epistemological beliefs.

Parallel to findings of the present study, Schommer (1990) demonstrated a significant relationship between parents' education level and students' beliefs about the simplicity of knowledge and the speed of knowledge acquisition. She found that those students who had more educated parents tended to believe less in the simplicity of knowledge and in the quickness of learning. In a similar vein, Conley et al. (2004) found that low SES and low achieving students had less sophisticated belief about knowledge. Trautwein and Lüdtke (2007) also found that certainty beliefs correlated significantly and negatively with SES. Although less has been known about the role of home environment on epistemological beliefs, the results of the present study were consistent with these findings. Present study indicated that students from parents with a high SES had more sophisticated epistemological beliefs than students from parents with low SES. Students with more educated parents were possibly exposed to richer scientific resources in their home environments, which might be the reasons of holding more sophisticated epistemological beliefs. In addition, students who had working mother have more sophisticated epistemological beliefs than unemployed mother. One of the possible reasons is that students who had working mother might have more encouragement toward independence. Because of their working conditions, mothers may spend limited time to support their children's education, which may result in more expectations from their children to take responsibilities for their own thinking and learning than those students who had unemployment mother. This might lead children of working mother to develop greater sophistication of epistemological beliefs.

Regarding gender effects on students epistemological beliefs, present study indicated that boys more likely to have tentative beliefs compared to girls. More boys than girls believed that knowledge is uncertain and not handed down by

authority. Girls were less likely than boys to see knowledge as tentative, developing and changing. Finally, no gender effect was found in fixed view. More recently, the study by Dogan and Abd-El-Khalick (2008) indicated that 10th grade Turkish students generally held informed views of some aspects of nature of science including tentative nature of scientific knowledge; the theory-driven nature of observation; and the role of error and probabilistic reasoning in science. They suggested that intended aims of the recent national reform in Turkey related to NOS can not be achieved if special attention is not given to teaching and learning NOS. Student views of some NOS aspects were also related to some of the variables such as gender, student household SES, parent education, and SES of their city and geographical region. Student views regarding tentativeness of scientific knowledge and the epistemological status of hypotheses were found to be related to whether their mother possesses a job, but not related to the nature of the mother's job. On the other hand, students' views were not associated with their gender as well as their father's job. They reported that 10th grade students having educated parents, and those living in cities and/or regions with higher SES tended to have "informed" views of many aspects of NOS. In a similar vein, students from higher income families held informed and/or had partially informed views compared to those from lower income families.

On the other hand, in terms of gender differences in epistemological beliefs, there are differing results in the literature. While some studies revealed no gender differences (Buehl et al. 2002; Chan and Elliott 2002; Schommer 1993; Schommer et al. 1997; Trautwein and Lüdtke 2007), others indicated significant differences in certain aspects of epistemological beliefs (Bendixen et al. (1998); Hofer 2000; Neber and Schommer 2002; Paulsen and Wells 1998; Schommer and Dunnell 1994). For instance, Bendixen et al. (1998) found that female students expressed more sophisticated beliefs with respect to the certainty of knowledge. They also reported that among certain knowledge, innate ability, quick learning, simple knowledge and omniscient authority, certain knowledge was the only belief that makes difference between girls and boys; boys expressed more sophisticated beliefs with respect to certainty knowledge. In her work with undergraduate students, Hofer (2000) demonstrated significant effect of gender for certainty/simplicity of knowledge and source of knowledge. She reported that boys compared with girls expressed greater beliefs about certainty of knowledge and viewed authority as the source of knowledge. Gender-related differences in epistemological beliefs were also revealed in another study identifying that boys have stronger belief in quick learning than did girls (Neber and Schommer 2002). A series of study conducted by Schommer and her colleagues reported significant effects of gender on two of the four epistemological factors. Particularly, girls were found to be less likely to believe in quick learning and fixed ability compared to boys (Schommer 1993; Schommer and Dunnell's 1994; Schommer et al. 1997). Schommer (1993) argued that girls might have a "slight epistemological advantage." Although she did not report any differences between boys and girls regarding simple and certain knowledge, they were found to demonstrate different beliefs about fixed ability and quick learning. On the other hand, result of present study indicated that boys had more desirable epistemological beliefs than girls. It seems quite plausible that in

schools girls may have less opportunity to engage in science activities. This might be a reason for the development of less sophisticated epistemological beliefs among girls compared to boys. However, it is necessary to note that in the present study, there was a small effect size regarding the gender difference. Therefore, the statistically significant difference found between boys and girls should be interpreted with a caution. Still, this study provides initial attempts to examine elementary students' epistemological beliefs in relation to gender in Turkish context. More work is necessary to explore in more depth to understand the origins of this gender difference.

In studying epistemological beliefs, one should carefully take the influence of cultural values into consideration. Chan and Elliott (2002) argued that the findings of epistemological beliefs can be context dependent. They noted that a few studies of epistemological beliefs in other cultures reported differences in their results due to the variations in cultural values. For that reason, researchers in this domain should use epistemological instruments and interpret their results with a caution. The current study, however, has some limitations to consider in any attempt to generalize the findings. The study was limited to self-reported data. Future research is needed to verify the consistency and accuracy of the findings through use of multiple methods and measures. We conducted this study with 1,152 eighth grade students at public schools located in a large urban area. Data from other school districts and from other school types might provide different results. The results may not be reliable if generalized beyond students enrolled in a similar situation and similar cultural context. Therefore, the generalization of the results from this study should be viewed with caution.

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