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The Effects of the Nature of Science Beliefs on Science Teaching and Learning

Gökhan Özdemir
Niğde Üniversitesi Eğitim Fakültesi İlköğretim Bölümü
gokhanozdemir@nigde.edu.tr

Abstract. This paper discusses how science teachers' beliefs about the nature of science affect their teaching orientations and how students' beliefs about the nature of science affect their learning orientations. Related research literature suggests that science teachers' and students' epistemological commitments about science often align with positivist naïve view. In turn, science teachers' instructions stress the objectivity and reproducibility of science and the products of science rather than the process of science. Students who have positivist naïve view adopt rote learning that leads them to memorization and meaningless learning. Considering the relationship between the nature of science beliefs and teaching and learning, this paper presents several educational implications including the constructivist approach as a shared epistemology for meaningful science learning. In light of recent research literature, this study also suggests explicit-reflective nature of science instruction embedded in scientific inquiry to enhance teacher candidates' and students' views of the nature of science.

Key Words: Nature of science, positivist view, constructivism, science teaching and learning.

Özet. Bu çalışmada, fen öğretmenlerinin bilimin doğası konusundaki inançlarının öğretim şekillerini ve öğrencilerin bilimin doğası konusundaki inançlarının öğrenme şekillerini nasıl etkiledikleri tartışılmaktadır. İlgili kaynaklar, fen öğretmeni ve öğrencilerinin bilim hakkındaki inançlarının çoğunlukla olgucu (pozitivist) bakışla örtüştüğünü göstermektedir. Bu yüzden fen öğretmenleri, öğretimlerinde bilimsel süreçten çok bilimin nesnelliğini, tekrar edilebilirliğini ve bilimsel ürünleri vurgulamaktadır. Olgucu bakışa sahip öğrenciler ise ezber ve anlamsız öğrenme yolunu seçemktedirler. Bu çalışmada bilimin doğası ile öğretme ve öğrenme arasındaki ilişki göz önünde bulundurularak, anlamlı fen öğrenimi için yapılandırmacı yaklaşımı, paylaşılan bir öğrenme felsefesi olarak görmeyi içeren, bir çok eğitimsel çıkarım sunulmaktadır. Ayrıca, son araştırmalar ışığında, öğretmen adaylarının ve öğrencilerin bilimin doğası hakkındaki görüşlerinin, bilimsel araştırma içine oturtulmuş, açık ve yansıtmacı öğretim ile geliştirilebileceği önerilmektedir.

Anahtar Kelimeler: Bilimin doğası, olgucu bakiş, yapılandırmacılık, fen bilgisi öğretimi ve öğrenimi.

I. Introduction

The purpose of achieving scientific literacy is one of the most significant educational goals. This goal has long been advocated by reform reports and science educators (e.g., American Association for the Advancement of Science [AAAS], 1989, 1993; Clough, 2000; National Research Council [NRC], 1996). In general, a scientifically literate person understands the concepts, principles, theories, and processes of science and is aware of the complex relationships between science, technology, and society. A scientifically literate person should also possess an ability to think and reason scientifically. In addition, an adequate understanding of the nature of science is seen as a major component of scientific literacy. Acquiring a coherent understanding of nature of science for science teachers and students requires more than learning scientific processes, solving problems and engaging in scientific activities (Taşar, 2003). Therefore, helping students develop an accurate and adequate understanding of the nature of science has been emphasized in major reform documents (AAAS, 1989, 1993; National Science Teachers Association [NSTA], 1982; National Research Council [NRC], 1996).

II. Nature of science: Old versus new views

The conceptualization of the nature of science has improved with developments in different scientific areas (Abd-El-Khalick & Lederman, 2000a). Kuhn's (1962) *Structure of Scientific Revolutions* has had a significant impact on contemporary understanding of the nature of science. Before Kuhn's work, the philosophy of science was dominated by the work of logical empiricists (Giere, 1988). In this old view, scientific claims were justified through a step-wise logical procedure. Philosophers were not interested in a descriptive account of how science actually works. This old conceptualization often looked for universal truths with the help of logic, observations, and mathematical applications (Edmondson & Novak, 1993). This objectivist conceptualization was dominant during the early twentieth century in education. Indeed, understanding "the scientific method" was seen as understanding the nature of science (Abd-El-Khalick & Lederman, 2000a).

In the modern view, scientific knowledge is acquired through a construction based on previous knowledge that continually evolves and does not exist independent of human experiences (Kuhn, 1962). Today, although there is no exact consensus concerning conceptualization of the nature of science, the nature of science generally refers to "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Lederman 1992, p. 331). The major reform documents that were cited previously emphasize that students should learn that the modern view of science characterizes scientific knowledge as: basically tentative and subjective; empirically based (based on and/or derived from observation of the natural world); derived from human inference, imagination, and creativity; socially and culturally embedded; and related to an understanding of observation and inference. Students should also know the relationship between scientific theories and laws. If students hold significant misunderstandings about the nature of science, this can negatively affect students' science learning, attitudes toward science, and the selection of further classes (Clough, 2000). In turn, scientific literacy is degraded Since this issue is so critical in science education, a considerable number of studies have been devoted to explore: (a) students' conceptions of the nature of science; (b) teachers' conceptions of the nature of science; (c) curricula and interventions to improve students' and teachers' conceptions of the nature of science; and (d) the relationship among teachers' conceptions, classroom practices, and students' conceptions (Lederman, 1992). There are also studies dealing with learning science and the nature of science. This paper will focus on how students' and teachers' beliefs about the nature of science affect science teaching and learning.

III. Teachers' Conceptions of the Nature of Science and Their Teaching Orientation

(i). Naïve epistemology/ Positivist perspective

Research reports have indicated that most teachers hold naïve or inadequate science philosophy (e.g., Gallagher, 1991; Lederman, 1992, Pomeroy; 1993 Yerrick, Parke & Nugent, 1997). Naïve epistemology indicates a positivist perspective describing scientific knowledge as true, real, and existing independently of personal experiences. Furthermore, the positivist or naïve approach treats science as a body of knowledge consisting merely of a collection of observations (Aguirre, Haggerty & Linder, 1990). One who has a naïve epistemology of science may not know the relationship between scientific theories and laws, the tentativeness of science, the place of imagination and creativity in scientific knowledge construction, and the limitations of science, and they may believe in a universal scientific method.

Lyons (1990) claims that teachers and students have interacting and interconnected epistemological perspectives and that identifying students' and teachers' epistemological positions is an important part of understanding the teaching and learning process. Based on similar assumptions, researchers have investigated how teachers' classroom practices are influenced by the teacher' conception of the nature of science (Aguirre et al., 1990; Akindehin, 1988; Billeh & Hassan, 1975; Brickhouse, 1989; Duschl & Wright 1989; Gallagher, 1991; Yerrick, et al., 1997; Yerrick, Pedersen & Arnason, 1998). The research provided empirical support for the assumption that science teachers' beliefs are consistent with their teaching orientations. Indeed, empirical evidence that will be mentioned below showed that teachers who have a naïve epistemology of science: stress the objectivity and reproducibility of science, focus on the products of science rather than the process of science, employ the teacher-directed approach, use traditional assessment methods, and have a lack of consideration of scientific theory in their instructions.

(ii). Naïve epistemology/ Stressing objectivity and reproducibility of science

Naïve epistemology assumes that scientific knowledge is out there and everybody can reach the same truth by following the same experimental procedure. This idea is one of the common misunderstandings of the nature of science among science teachers that scientists follow a single step-wise procedure, "the scientific method" (consisting of problem statement, hypothesis, observation, testing hypothesis, and drawing a conclusion) at their work (McCommas, 1996). Unfortunately, many science teachers begin activities by introducing this procedure as the single scientific method in their instruction (Gallagher, 1991). For example, the science teachers in Brickhouse's study (1989) held beliefs consistent with their teaching orientations that one teacher who believes in the existence of "the scientific method" encourages students' to use the step-wise procedure in the lab activities. The purpose of the activities was to follow the directions given in the textbook to reach predetermined right answers. A second teacher who had similar conceptions encouraged students to find expected results while stressing the objectivity and reproducibility of science.

(iii). Naïve epistemology/ Stressing product of science

It is expected that teachers should stress the process of science rather than product of science in their instruction. When teachers believe that scientific knowledge consists of merely facts and truths to be delivered to the students, they will overemphasize the products of science in teaching, neglecting the process of science. Yerrick et al. (1997) consistently found that most teachers set up their science instruction around fixed knowledge. On the other hand, teachers concerned with the construction of scientific knowledge will also be interested in teaching the process of science, which leads them to pay more attention to their students' interpretations.

(iv). Naïve epistemology/ Stressing teacher directed approach

Teachers' epistemological commitments of the nature of science affect whether they employ teacher centered or student centered instruction. Laplante (1997) observed two teachers whose beliefs were largely aligned with Logical Positivism (or Logical Empiricism). Their classroom practices reflected that their instructional strategies were teacher directed. The teachers largely used the teacher directed approach with closely controlled activities, emphasized transmission of knowledge, and considered students as simple receptors of that knowledge. What he concluded was that "these teachers promote in their classrooms a rapport with knowledge which is not empowering for the students as they are not considered autonomous knowers in science or inquirers in their own right. At best, they are the receivers of knowledge constructed by others and transmitted by teachers. Given these circumstances, the cognitive potential of students as knowers in science in unlikely to develop fully" (p. 287).

(v). Naïve epistemology/ Stressing traditional assessment formats

Teachers' understanding of the nature of science is also strongly affects teachers' assessment choices. The teachers in the study by Yerrick's et al. (1998) largely used traditional assessment methods such as quizzes, unit test, true/false, multiple choice, matching, drawing and labeling, fill in the blanks, short answer, and essay test in grading. None of the teachers in the study talked about portfolios, rubrics, journals, open ended items, or performance assessment in grading of student performance. Once the assessment is in traditional fashion, students accept authority of scientific knowledge and teachers' interpretations without questioning or agreeing of them (Yerrick et al., 1998). Students just look for correct scientific answers that are expected by teachers. Such teaching orientation leads students to use rote memorizations and meaningless learning. "Teachers who view teaching as the transmission of knowledge will often view knowledge as a package to be sent that arrives complete and unchanged. Once students have received this knowledge the teacher's questioning and assessment consists mainly of short answer questions to assure the teacher repeatedly that knowledge has arrived" (Yerrick, et al., 1997, p.140). In contrast, the teachers who have developed constructivist epistemology of science preferred to use student centered teaching, use formative assessment formats, and focus on students' interpretations rather than those of their textbooks (Yerrick, et al., 1997).

> According to Yerric, et al. (1997), there is a close relationship between teachers' epistemological commitments of science and their assessment choices. In their view, having contemporary view of science leads teachers to employ formative assessments in their instruction. In contrast, having serious misconceptions of the nature of science leads teachers to employ traditional assessments in their instructions. However, this issue requires further studies to fully explore these relationships and to make a strong conclusion whether teachers' assessment strategies can be merely interpreted on the basis of teachers' epistemological commitments of science.

(vi). Naïve epistemology/ Absence of scientific theories

Naïve epistemology leads teachers to the lack of consideration of scientific theories in their instructional tasks. Without considerations of major explanatory statements, teachers' instruction is only developed within scientific facts and truths. Doymuş, Canpolat, Pınarbaşı, and Bayrakçeken (2002) investigated the understanding of "theory" among preservice science teachers and first year students from the same department. They found that there were no significant differences between these groups regarding the interpretation of "theory." In their study, only one out of 51 preservice science teachers held a meaning of theory that was close to the true definition of theory. Duschl and Wright (1989) found a positivist view of science among science teachers who were committed "hypothetico-deductive philosophy of logical positivism" (p.491). In that study, the teacher who treated the scientific process as separate from theories did not stress in his instruction that theories are interpretations of observations. On the other hand, another teacher who believed that conceptual frameworks are required as guidance for observations discussed observations by considering scientific theories and vise versa in her instruction (Wright, 1989).

It is expected that teachers should know the relationships between theory, laws and observations and should stress the process of science rather than only facts and laws (e.g., Akerson, Abd-El-Khalick, & Lederman, 2000). Actually, demonstrating the process of science by emphasizing the explanatory power of prominent scientific theories could be an effective approach for explaining how scientific knowledge is constructed (Duschl & Wright, 1989). For example, since scientists first developed an atomic theory, the theory has changed drastically over time, but teachers still continue to teach different (outdated) atomic models that have been suggested by scientists over the years. Discussing science problems and making observations in the light of major scientific theories is valuable in science teaching from many respects (Abd-El-Khalick & Lederman, 2000b). Elaborating on the example of atomic theories: first, the development of atomic theory shows that a theory can change over time. Second, although scientists could not directly observe atoms, they were able to infer their existence through data. Third, different atomic models have been developed by imagination and creativity. Finally, even though atoms were not seen with direct observation, scientists have dealt with molecular structures by taking the existence of atoms for granted.

On the basis of aforementioned literature, teachers' science view affects their classroom practices. There is a discouraging argument regarding previous research findings that although some teachers have developed a real understanding of the nature of science, it is not necessary that their teaching approaches are totally committed to communicating this understanding to help promote their students' conception of the nature of science due to external factors such as curriculum constraints, administrative policies, and supplies (Lederman & Zeidler, 1987). Lederman and Zeidler (1987) also noted "a more balanced treatment of the history/philosophy of science and specifically targeted behaviors/skills needed in pre-service and in-service science-teacher education if we are to successfully promote more adequate conceptions of the nature of science among our science students." Teachers need to apply their skills and knowledge without worrying about the external factors. When teachers fail to develop appropriate conceptions of the historical, philosophical, and sociological foundation of science, a number of successful students chose different majors (Tobias, 1990). This might result in a serious problem for the future that the developments of science enterprises and scientific literacy can be undermined.

IV. Students' Conceptions of the Nature of Science and Their Learning Orientation

(i). Naïve epistemology/ Positivist perspective

While teachers' epistemological commitments to the nature of science affects their role in building students' conception of scientific knowledge, students' naïve theories, preexisting knowledge, and experiences have an impact on science learning (Edmondson & Novak, 1993). Research that has examined students' views on the epistemologies of science has indicated that students' views about the nature of science range from positivist to relativist (e.g. Edmondson & Novak, 1993, Ryan & Aikenhead, 1992). However, the majority of students in the studies hold positivist views about the nature of science. For example, Ryan and Aikenhead (1992) examined 11^{th} and 12^{th} grade students' epistemological commitments on seven issues, which were (1) the meaning of science, (2) scientific assumptions, (3) values in science, (4) conceptual inventions in science, (5) the scientific method, (6) consensus making in science, and (7) characteristics of the knowledge produced in science. They found that students largely held inadequate and inappropriate beliefs about nature of science. First, students' perspectives confused science with technology. When they were talking about science, they were actually referring to technology. Second, they were not aware of the influence of scientists' values including religious, ethical, masculine, and feminine factors on scientific knowledge construction. Third, their naïve conceptions about hypothesis, theory, and law led them believe in the hierarchical relationship in which hypothesis become theories and theories become law. Fourth, students believed in step-wise procedure as the scientific method and ignored imagination and creativity in scientific knowledge construction. Finally, some students believed in the tentativeness of scientific knowledge but the reasons behind their views were that either old facts change to different facts or old facts become wrong facts. A number of studies that were cited previously found similar naïve epistemology of science among students.

While students' epistemological commitments have been in favor of positivism, a considerable number of researchers have turned their attention to investigate how students' nature of science views influence their learning in science with the assumption that students' beliefs about the nature of science are indicators for their learning orientations (Edmondson & Novak, 1993; Reif & Larkin, 1991; Roth & Roychoudhury, 1994; Ryan & Aikenhead, 1992; Songer & Linn, 1991; Smith, 1991; Tsai, 1998, 1999; Wallace, Tsoi, Calkin & Darley, 2003; Yerrick et al., 1998). The research reports documented that students who have a naïve view of science focus on factual knowledge, accept scientific knowledge without reasoning and questioning, and have a lack of consideration for everyday experiences while they learn science. Overall, such learning flaws lead students to rote memorization and meaningless learning. In turn, rote memorization helps them acquire some misconceptions or reinforce and retain their misconceptions.

(ii). Naïve epistemology/ Focusing on factual knowledge

Students who have a positivistic view of science focus on factual knowledge (e.g., Reif & Larkin, 1991). Scientific knowledge is understood as a collection of facts, truths, and formulas rather than a conceptual structure allowing us to produce alternative hypothesis to test. Therefore, understanding science is equated with memorizing formulas, laws and computation in students' minds. This perception leads students to acquire "inert knowledge which is not flexibly usable" (Reif & Larkin, 1991 p. 740).

(iii). Naïve epistemology/ Lack of questioning and reasoning

Students often accept scientific knowledge without reasoning and questioning (Edmondson & Novak, 1993) because of their naïve epistemological commitments. They accept existing knowledge coming from textbook and from teachers even if the scientific knowledge conflicts with their everyday experiences. For example, since students learn in school that the shape of the earth is round, in spite of their own different observations that the shape of the earth is flat, students claim that the shape of the earth is round without knowing underlying reasoning. They learn the facts without understanding and interpreting underlying principles (Posner, Strike, Hewson, & Gertzog, 1982). According to Posner et al. (1982), if a learner's current conception is functional and if the learner can solve problems within the existing conceptual schema, then the learner does not feel a need to change the current conception. Even when the current conception does not successfully solve some problems, the learner may make only moderate changes to his or her conceptions. In such cases, the assimilations go on without any need for accommodation. It is believed that the learner must be dissatisfied with an initial conception in order to abandon it and accept a scientific conception for successful conceptual change. Poster et al. (1982) also identified three additional conditions for successful conceptual change. The scientific conception must be intelligible, plausible, and fruitful for successful conceptual change to occur. Intelligible means that the new conception must be clear enough to make sense to the learner. Plausible means the new conception must be seen as plausibly true. Fruitful means the new conception must appear potentially productive to the learner for solving current problems.

(iv) Naïve epistemology/ Reinforcing and retaining misconceptions

When scientific knowledge is taught as disconnected from everyday experiences that again leads to the familiar conclusions, memorizations and meaningless learning. It reinforces existing misconceptions and can even generate new ones. Conceptual change literature indicates that students even in very early ages hold misconceptions that are highly resistant to change (e.g., Carey, 1985). The efforts made to change students' conceptual framework with direct instruction would not be sufficient because students' epistemological commitments have an impact on their learning of science (Strike & Posner, 1982).

Students' misconceptions of science contents sometimes result from their wrong perceptions on the instructional materials and/or tools. For example, Smith (1991) investigated students' perceptions about scientific models by comparing and contrasting them to scientists' views. While scientists' views about scientific models were consistent with a constructivist framework that models are used for the purposes of constructing and testing ideas and communications, students' views reflected a naïve epistemological view that scientific models represent physical copies of reality. However, students need to understand that scientific models are just a tool of inquiry; it does not imply what is actually out there. Simply accepting scientific models as packages of facts does not make students think about underlying theories and implications, especially for abstract concepts in science.

The literature above shows that students often demonstrate naïve science views and these views have negative impact on their learning orientations. Research results also indicated that some students cannot be classified as totally positivist or relativist, but instead belong to a mix group whose beliefs are a mixture of the two (Edmondson, 1989; Roth & Roychoudhury, 1994). Indeed, the majority of the students in Edmondson's study represent a mix group. While students describe science according to the logical positivist view and as something isolated from their experiences, they were able to display some thoughts consistent with relativist view. They may treat themselves as relativists for outside of school subjects, but adopt positivist views during academic life. Holding such conflicting views leads to a vague understanding in science learning. However, holding conflicting beliefs of the nature of science is not surprising for even teachers, as stated above. Hence, one possibility is that embracing constructivism as a learning theory would be appropriate solution to negotiate meanings of knowledge in classrooms when teachers or students hold inappropriate and inadequate science views. Then, constructivist environment provide necessary room for teachers and students to acquire the essential elements of the nature of science.

V. Discussions and Implications

(i). Constructivist epistemology and meaningful learning

Much of the research cited in this paper was based on the distinctions drawn between meaningless and meaningful learning and positivist and constructivist view of science (e.g., Edmondson & Novak, 1993; Reif & Larkin, 1991; Roth & Roychoudhury, 1994; Ryan & Aikenhead, 1992; Yerrick et al., 1998). Meaningless learning refers to memorization and acquisition of knowledge without making sense of it. When students passively receive scientific knowledge instead of constructing it with the integration of their prior knowledge, it is difficult for them to build a coherent conceptual knowledge structure for meaningful learning. Consequently, students' scientific knowledge becomes fragmented. Students' incoherent knowledge leads them to believe that science is hard and includes too many formulas and laws to remember. On the other hand, students who have coherent and well-organized scientific knowledge understand the relationship between events and are able to apply their knowledge to novel situations with enjoyment. Meaningful learning requires relevant prior knowledge and engagement to make sense of incoming knowledge. Achieving meaningful learning and teaching implicitly requires adopting of a constructivist epistemology and learning beliefs (Edmondson & Novak, 1993; Tsai, 1998).

Social constructivism suggests that learning is a productive process in which learners actively construct their own meaning with social interaction (Vygotsky, 1978). A learner tests his/her understanding by interacting with the other individuals. The community that we are interacting with has the greatest potential to test and stimulate our ideas and to elaborate and extend our learning. The important impact of constructivist epistemology on learning is a search for the most "viable" interpretation of phenomena (von Glasersfeld, 1989). Scientific interpretation of a certain phenomena is based on a widespread agreement within a scientific community. It is not because there are some universal truths (von Glasersfeld, 1993). Regarding the process of constructing scientific knowledge, we want students to go through the same process as scientists do. Therefore, teachers need to value constructivism and employ constructivist-teaching strategies in their instruction to bring a small scientific community atmosphere into the classroom.

(ii) Constructivism as shared epistemology

The literature investigating the relationship between the nature of science and teaching and learning revealed that teachers and students should embrace constructivist epistemology to create an ideal environment for science teaching and learning. Transforming teachers' views from positivism to constructivism alone would not provide an effective outcome in education for the students who hold positivists beliefs about knowing and learning. Such students could not be active participants during science investigations since they still hold a conception about learning as "getting things right". Similarly, only transforming students view from positivism to constructivism would not provide an effective educational outcome if teachers still hold positivist beliefs about teaching. In this case, students could scarify their own scientific thinking in favor of teachers' views for the sake of grades, success, and academic survival (Edmondson, 1989). Another possible consequence was documented by Yerrick et al., (1998) that while the physics teacher who held positivist beliefs displayed authoritarian pedagogy, a student who held constructivist beliefs displayed disengagement and challenge. What I argue here is that both students and teachers need to have the same epistemological position, and that this shared position must be constructivism for developing meaningful learning. Therefore, constructivist epistemology and the nature of science is not to be emphasized only in science method courses but should also be important components of all traditional science courses offered at any level (Bağcı-Kılıç, 2003) if our priority is to increase scientific literacy along with meaningful science learning.

VI. Conclusion

Current emphasis on achieving scientific literacy is strongly urging teachers and students to hold adequate and contemporary beliefs of the nature of science (NRC, 1996). This is because research on teaching and learning has provided strong empirical support for the relationship between teachers' and students' beliefs of the nature of science and their respective teaching and learning orientations. However, both teachers' and students' beliefs systems are far behind the current reform expectations and heavily depend on positivist naïve view about science, teaching, and learning.

Teachers have inadequate or inappropriate views of the nature of science because they most likely have had very little opportunity to study about it. Furthermore, their scientific education has focused on the body of knowledge of science, and it has given very little emphasis to the process of science by which scientific knowledge is constructed and validated in their school life. In turn, their classroom practices reflect their beliefs about science so that students do not learn how scientific knowledge is formulated and validated. They overemphasize the factual basis of science with traditional assessment formats and fail to characterize scientific knowledge as tentative, and scientific work as creative. Teachers' instructions stress the objectivity and reproducibility of science and the products of science rather than the process of science. They often employ the teacher directed approach, and have a lack of consideration of scientific theory in their instruction. As a consequence of such beliefs and practices held by teachers, students develop similar positivist perspectives about science and learning. Students adopt rote learning that leads them to memorization and meaningless learning.

To remedy this situation, characteristics of the nature of science should not only be taught as a part of science teaching method courses, but also embedded in science courses. The concept of nature of science should be treated as a central piece of science teaching and learning in all science classes because recent research findings indicated that acquiring appropriate view of science requires more than short term interventions (Abd-El-Khalick & Akerson, 2004; Akerson et al., 2000). Of course, using inquiry should be a vehicle to promote the view of the nature of science but teaching the essential elements of the nature of science with explicit-reflective approach rather than implicit instruction in the context of scientific inquiry (Schwartz & Lederman, 2002) would provide a higher outcome. In the latest long term study, Akerson and Hanuscin (2007) found that teachers positively changed their elementary students' views of the nature of science when they engaged in explicit-reflective activities embedded in scientific inquiry and inquiry-based instructions.

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Bilimin Doğası Konusundaki İnançların Fen Bilgisi Öğretimi ve Öğrenimine Etkileri

Özet

Bu çalışmanın amacı bilimin doğası hakkındaki inançlar ile fen öğretimi ve öğrenme arasındaki ilişkiye dikkat çekmektir. Bu amaçla, bu çalışmada iki adet araştırma sorusu irdelenmektedir: (1) Öğretmenlerin bilimin doğası hakkındaki inançları, onların öğretme şekillerini nasıl etkiler? (2) Fen bilgisi öğrencilernin bilimin doğası hakkındaki inançları, onların öğrenme şekillerini nasıl etkiler?

Bilimsel okuryazarlığı elde etme amacı eğitimin en önemli hedeflerinden biridir (American Association for the Advancement of Science [AAAS], 1989, 1993; Clough, 2000; National Research Council [NRC], 1996). Bilimsel olarak okuryazar bir birey olmanın ölçütlerinden biri, bilimin doğası hakkında yeterli düzeyde bir anlayışa sahip olmaktır. Çağdaş bilim

bakışı, bilimsel bilgiyi şu şekilde karekterize eder: Temelde değişime açık ve göreceli; ampirik tabanlı (doğanın gözlemlenmesi üzerine kurulmuş ve/veya doğanın gözlemlenmesinden türemiş); insanoğlunun yaptığı çıkarım, hayalgücü ve yaratıcılığından türemiş; sosyal ve kültürel tabana oturtulmuş ve gözlem ile çıkarımların anlaşılmasıyla ilgilidir (Lederman, 1992). Fakat birçok öğretmen ve öğrencinin bilimin doğası hakkındaki inançları olgucu ve zayıf bakışla örtüşmektedir. Olgucu ve zayıf bakış, fen bilgisi öğretme ve öğrenme sürecine çok olumsuz yönde etki etmektedir.

Bu calışmadaki temel veri kaynakları, bilimin doğası hakkındaki inançlar ile fen öğretme ve öğrenme arasındaki ilişkiyi araştıran ampirik çalışmalardır. Bu çalışmada, bu konu üzerine yapılmış daha önceki çalışmalardan elde edilmiş olan temel argümanların sentezi yapılmıştır. Ayrıntılı olarak, zayıf episdemik bilim anlayışına sahip öğretmenler bilimin nesnelliğini ve tekrar edilebilirliğini vurgular, bilimsel süreçten çok bilimin ürünlerine odaklanır, öğretmen merkezli yaklaşımı benimser, geleneksel değerlendirme yöntemleri kullanır ve öğretimlerinde bilimsel teorileri gözönünde bulundurmazlar (Aguirre et al., 1990; Akindehin, 1988; Billeh & Hassan, 1975; Brickhouse, 1989; Duschl & Wright 1989; Gallagher, 1991; Yerrick, Parke & Nugent, 1997; Yerrick, Pedersen & Arnason, 1998). Öğrencilerin olgucu ve zayıf bakışı ise onları ezbere ve anlamsız öğrenmeye götürür (Edmondson & Novak, 1993; Reif & Larkin, 1991; Roth & Roychoudhury, 1994; Ryan & Aikenhead, 1992; Songer & Linn, 1991; Smith, 1991; Tsai, 1998, 1999; Wallace, Tsoi, Calkin & Darley, 2003; Yerrick et al., 1998). Zayıf bilim bakışına sahip öğrenciler olgulara dayanan bilgiye (factual knowledge) odaklanır, bilimsel bilgiyi muhakeme etmeden ve sorgulamadan kabul eder, ve fen bilgisini öğrenirken günlük deneyimlerini gözönünde bulundurmaz. Genel olarak öğrenmedeki bu kusurlar öğrencileri ezbere ve anlamsız öğrenmeye götürür. Bunun sonucu olarak öğrenciler birtakım kavram yanılgıları kazanır veya varolan kavram yanılgılarını barındırmaya devam eder ve pekiştirir. Bu durumda öğrenciler ne çağdaş bir bilim anlayışı geliştirebilir nede bilimsel olarak okuryazar bireyler olabilirler.

Öneri olarak bilimin doğasının karekteristik özellikleri sadece fen bilgisi öğretim yöntemleri derslerinde değil ayrıca fen bilgisi alan derslerinin içinde de öğretilmelidir. Bilimin doğası kavramı fen bilgisi öğretimi ve öğreniminde temel bir unsur olarak düşünülmelidir. Öğrencilerin bilimin doğası hakkındaki görüşlerini geliştirmek ve onlara gerekli şartları hazırlamak için, yapılandırmacılık en uygun öğrenme teorisi olabilir. Yapılandırmacı öğrenme teorisinin rolü ve diğer eğitimsel cıkarımlar bu çalışmada tartışılmıştır.