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The Nature of Science as Viewed by Science Teachers in Najran District, Saudi Arabia

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Abstract
This study aims to investigate the views of Saudis Science Teachers in Najran district about the nature of science (NOS). A questionnaire of fourteen items was developed and administered to a sample of 83 science teachers. The questionnaire covers five aspects of the nature of science which are: scientific theories and models; role of scientists; scientific knowledge; scientific method; and scientific laws. Findings showed that the majority of the teachers in this study held uninformed conceptions about most of the target NOS aspects. At the same time, no differences were found between males and females regarding their informed conceptions about NOS. The results suggest that further research is required to better understand how Saudi teachers display NOS in their classes and how the pedagogies of teacher education inform this displaying.
Keywords: key words, orkforce sizing, job-shop production, holonic model

1. Introduction

The history of the advocacy for teaching of nature of science (NOS) in science classrooms is very long and is evidenced by the National Society for the Study of Education (1960) and Hurd (1960) who claim the existence of this goal in American schools as early as 1920 (Karakas, 2010). The National Research Council (NRC) has clearly stated the most recent objectives of science education: (1) science is a way of knowing that is characterized by empirical criteria, logical argument, and skeptical review, and (2) students should develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture. (NRC, 1996).

During the past 80 years, almost all scientists, science educators, and science education organizations have agreed on the objective of helping students develop informed conceptions of NOS (Abd-El-Khalick, Bell, & Lederman, 1998; Duschl, 1990; Meichtry, 1993). Currently, and despite their varying pedagogical or curricular emphases, there is an agreement among the major reform efforts in science education (American Association for the Advancement of Science [AAAS], 1990, 1993; National Research Council [NRC], 1996) about the goal of enhancing students' conceptions of NOS. However, research has consistently shown that kindergarten through Grade 12 (K–12) students, as well as teachers, have not attained desired understandings of NOS (Abd-El-Khalick & Lederman, 2000a; Duschl, 1990; Lederman, 1992). Several attempts have been undertaken to enhance students and science teachers' NOS views (Akerson, Abd-El- Khalick, & Lederman, 2000; Billeh & Hasan, 1975; Carey & Stauss, 1968; Haukoos & Penick, 1983; Jelinek, 1998; Ogunniyi, 1983; Olstad, 1969).

An understanding of NOS is considered as a key element of scientific literacy (American Association for the Advancement of Science [AAAS], 1993; Bybee, 1997; Miller, 1983; Organization for Economic Co-operation and Development [OECD], 2006; Osborne, 2007), which is advocated worldwide as a goal of school science education (AAAS, 1993; De Vos & Reiding, 1999; Goodrum, Hackling, & Rennie, 2001; Millar & Osborne, 1998; National Research Council [NRC], 1996). Moreover, an understanding of NOS is considered important in enhancing students' understanding of science, successful learning of science content, and participating in socio-scientific decision making (Driver, Leach, Millar, & Scott, 1996; McComas, Clough, & Almazroa, 1998). Science curricula worldwide, therefore aims to help learners attain an adequate understanding of NOS.

NOS has been defined in many ways in science education literature (Karakas, 2008, 2010). In spite of the significant progress toward characterizing science, there is no single NOS definition that fully describes all scientific knowledge and enterprises (Schwartz & Lederman, 2002) and there is always likely to be an active debate at the philosophical level about what NOS is (McComas, 1998, as cited in Karakas, 2010). However, at the level of helping individuals understand the basics of science in order to promote science literacy, there is some basic agreement about NOS among science educators that scientific knowledge is tentative, empirically based, subjective, partly the product of human inference, imagination, and creativity, and socially and culturally embedded (Lederman, Abd-El-Khalick, & Akerson, 2000). Two additional important aspects are the distinction between observations and inferences, and the functions of and relationships between scientific theories and laws (Lederman et al., 2000).

2. Literature Review

2.1. The Nature of Science

The nature of science encompasses various fields, especially epistemology, which involve how scientific knowledge is generated and the character of science (Lederman, 1992). McComas, Clough, and Almazroa (1998) provide a good overall description of the NOS: "The nature of science is a fertile hybrid arena, which blends aspects of various social studies of science including the history, sociology, and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors." (p. 4). From an analysis of some international science standard documents, those authors (McComas, Clough, & Almazroa, 1998) summarized a consensus view of the NOS. Some aspects of the NOS are: scientific knowledge; scientific method; laws and theories; scientists are creative; and science and technology (McComas, Clough, & Almazroa, 1998).

2.2. Science Teachers' Conceptions of the Nature of Science

With the use of different methods and instruments, the literature suggests that most science teachers possess an inadequate understanding of the NOS. Their conceptions of the NOS are mixed, unsolidified, and confused (Abd-El-Khalick & BouJaoude, 1997; Dogan & Abd-El-Khalick, 2008; Haidar, 1999). Also, there is no significant relationship between science teachers' academic background or personal antecedents in school and their conceptions of the NOS (Carey & Stauss, 1970; Lederman, 1992; Mellado, 1997). The studies related to conceptions of the NOS held by science teachers can be categorized in four major groups: scientific knowledge, scientific method, scientists' work, and scientific enterprise.

2.3. Scientific Knowledge:

In various studies, a majority of science teachers had a simple conception regarding a hierarchical relationship between hypotheses, theories, and laws (Abd-El-Khalick & BouJaoude, 1997; Dogan & Abd-El-Khalick, 2008; Haidar, 1999; Rubba & Harkness, 1993). They believed that when a hypothesis is proven correct, it becomes a theory. After a theory has been proved true many times by enough evidence, it becomes a law. Accordingly, scientific theories were a lesser type of knowledge than laws (Akerson, Morrison, & McDuffie, 2006; Akerson & Donnelly, 2008). The availability or accumulation of supporting evidence was also linked with the status of the truth or correctness of hypotheses, theories, and laws (Dogan & Abd-El-Khalick, 2008). The conception that these constructs are different types of ideas was not grasped (Abd-El-Khalick & BouJaoude, 1997). In addition, many of science teachers confused a scientific theory with a scientific fact. They believed that theories were facts before being proven by experiment (Tairab, 2001).

Scientific models, as viewed by the most of science teachers, are copies of reality which is a popular uninformed conception of the NOS (Dogan & Abd-El-Khalick, 2008). Scientific models, in their view, are copies of reality rather than human inventions (Abd-El-Khalick & BouJaoude, 1997) because scientists say they are true or because much scientific observations and/or research have shown them to be true (Dogan & Abd-El-Khalick, 2008). However, many teachers, especially those who hold constructivist views, can articulate the role of scientific models as scientists' best ideas or educated guesses to represent reality rather than exact copies of experienced phenomena (Haidar, 1999).

2.4. Scientific Method

The scientific method is commonly perceived by science teachers as a universal step-wise method (Abd-El-Khalick & BouJaoude, 1997; Dogan & Abd-El-Khalick, 2008; Haidar, 1999). This can be attributed to the science curriculum that presents the scientific method as a sequence of steps that all students have to followed exactly in order to reach certain results (Haidar, 1999) or unambiguous scientific truth (Brickhouse, 1990). For a majority of science teachers, good scientists were, therefore, those who follow a recipe— the steps of the scientific method—in their investigations (Abd-El-Khalick & BouJaoude, 1997; Haidar, 1999).

2.5. Scientists' Work

The most common bipolar conceptions of the NOS are subjectivity and objectivity, theory-laden and theory-free. For most science teachers, subjectivity plays a major role in the development of scientific ideas (Abd-El-Khalick & BouJaoude, 1997) because scientists' worldviews or paradigms can affect their scientific thinking and decision- making (Lunn, 2002). However, many science teachers strongly believed in objectivity in science, which is firmly based upon theory-free or value-free observation. For example, nearly half of science teachers held the simple conception that observation is not influenced by the theories that scientists hold (Brickhouse, 1990; Dogan & Abd-El-Khalick, 2008; Haidar, 1999). Most science teachers adopted the idealistic view that the scientists' interpretation was objective and far from their frames of reference (Abd-El-Khalick & BouJaoude, 1997; Rampal, 1992).

The role of creativity and imagination in the construction of scientific ideas is overlooked by most science teachers because they believe that scientists must follow a fixed-step scientific method (Abd-El-Khalick & BouJaoude, 1997). Few science teachers recognized the importance of creative and imaginative aspect in scientists' work (Akerson, Morrison, and McDuffie, 2006; Rampal, 1992). In this case, creativity seems to be stereotypically dissociated from perceived scientific qualities. Some of science teachers argued that if scientists used creativity and imagination then they would not come up with accurate results (Akerson & Donnelly, 2008).

2.6. Scientific Enterprise

The social and cultural influences on the scientific enterprise are clearly recognized by science teachers (Akerson, Morrison, & McDuffie, 2006; Brush, 1989). For example, approximately half of science teachers in Haidar (1999) and Rubba and Harkness (1993) indicated that a scientist is influenced by social factors. In addition, most of science teachers in Tairab's study (2001) expressed the view that science and technology affect society and in turn society affects science and technoscienceology. However, few of science teachers believed that while collecting or presenting information a scientist is influenced by social biases. They regarded the authoritative image of the scientist as accurate (Rampal, 1992).

The interaction between science and technology represents an easy task for science teachers to be recognized. Science is the knowledge base for technology, and technology influences science advancement (Rubba & Harkness, 1993). However, distinguishing between science and technology is probably a very difficult task for them (Rubba & Harkness, 1993; Ma, 2008). Most of science teachers had a conception that technology is applied science (Tairab, 2001).

Few studies have been conducted in Saudi Arabia on aspects of the nature of science. Of those studies, a study conducted by Aldahmash & Alshamrani (2012) which its findings indicate that male science teachers have better understanding of the nature of science aspects than females. Also, Azobi (2009), confirms the existence of a relationship between science teachers understanding of the nature of science and their scientific attitudes. This study aims to contribute to the relatively limited literature on science teachers' conceptions of NOS. The findings coming up from this study may inform involved stakeholders about the current state of science teachers' understanding of NOS and subsequently take the necessary steps guide them for planning training programs to promote science teachers' understanding of NOS in Saudi Arabia. The research questions that guide this study are:

1. What are science teachers' conceptions of NOS?
2. Are there significant differences on teachers' beliefs of NOS regarding gender and years of experiences?

3. Methodology

3.1. Population and Sampling

The population of this study is the science teachers in Najran region. The population comprises both males and females in Najran districts. A sample of 20% was randomly chosen from this population. Forty one female science teachers and forty two male science teachers were responding to the items of this questionnaire.

3.2. Instrumentation and Procedures

The instrument that was used to gather the primary data for the study is a questionnaire. The questionnaire items were developed by the author considering a variety of nature of science instruments. Especially, those were successfully employed to explore science teachers' views of nature of science in an Arabian context to be applicable to Saudis' respondents. The questionnaire of fourteen items was distributed to 15 university professors in the area of science education. They were asked to examine the questionnaire items. At the same time, the coefficient of 0.85 was considered a highly acceptable indicator of the reliability of this survey. Questionnaires have been distributed to the participants in the academic year 2014/2015, at the begging of the second semester. All science teachers administrated the questionnaires in week 10 of the semester.

4. Results

4.1. Teachers' conceptions of the nature of scientific knowledge

Table 1. Science teachers' conceptions of the nature of scientific knowledge.

Statement	Agree (%)	Uncertain (%)	Disagree (%)
Hypotheses are only developed to become theories	70.6	5.7	23.7
Scientific theories are less secure than laws	58.5	14.7	26.8
Scientific theories can be developed to become laws	71.7	15.0	13.3
Scientific knowledge cannot be changed	33.3	4.5	62.2
Accumulation of evidence makes scientific knowledge more stable	65.0	11.1	23.9
A scientific model (e.g., the atomic model) expresses a copy of reality	63.9	14.1	21.0
Scientists do not use creativity and imagination in developing scientific knowledge	28.0	11.8	60.2
Scientists are open-minded without any biases	73.7	12.3	14.0

As shown in table I, most of science teachers in this study (70.6%) agreed with the statement, "hypotheses are only developed to become theories." At the same time, 23.7% of the teachers disagreed with this statement, while 5.7% of the respondents were uncertain. Regarding the statement "scientific theories are less secure than laws," a majority of science teachers (58.5%) agreed with this issue, a number of the participants (14.7%) were uncertain, and a good number (23.7%) disagreed. More than seventy percent of the participants expressed that a theory can be developed to become a law, while 13.3% disagreed, and 15% were undecided.

Table 1 also shows that a majority of science teachers thought that scientific knowledge can be changed (informed view about the tentativeness of scientific knowledge). At the meantime, 33.3% of the teachers expressed the uninformed view about this statement. Sixty five percent of the participants held uninformed view regarding the statement "accumulation of evidence makes scientific knowledge more stable", while, 23.9% expressed the informed view of this issue.

Most of the teachers in this study (63.9%) agreed on the statement of scientific model which means that the majority of science teachers held an uninformed conception on this statement. Only 21% of the teachers held informed conception on the scientific model, and 14.1% of them were uncertain. Science teachers' responses on the creativity and imagination indicated that a majority (60.2%) agreed, while 28% of them held uninformed perception. Finally, regarding the statement "scientists are open-minded without any biases", most of the participants (73.7%) held informed conception, while 14% of them disagreed.

4.2. Teachers' conceptions of the nature of scientific inquiry

Table 2. Science teachers' conceptions of scientific inquiry.

Statement	Agree (%)	Uncertain (%)	Disagree (%)
The scientific method is a fixed step-by-step process	80.9	4.3	14.8
Science and the scientific method can answer all questions	33.4	18.5	48.1
Scientific knowledge only comes from experiments	64.0	5.1	30.9

Table 2 shows that a majority of science teachers in this study (80.9%) held an uninformed conception that the scientific method is a fixed step-by-step process, while, 14.8% had informed view regarding this issue. Approximately half of the respondents (48.1%) disagreed with the statement that "science and the scientific method can answer all questions." While a good number of participants (33.4%) had an uninformed view about this statement, and a small number (18.5%) were uncertain. A majority of the participants (64%) possessed an uninformed view that "scientific knowledge only comes from experiments. On the other hand, a good number of participants (30.9%) had contemporary view about this issue.

4.3. Teachers' conceptions of the nature of scientific enterprise

Table 3. Science teachers' conceptions of scientific enterprise

Statement	Agree (%)	Uncertain (%)	Disagree (%)
Science and technology are identical	64	5.8	30.2
Scientific enterprise is an individual enterprise	30.1	14	55.9
Society, politics and culture do not affect the development of scientific knowledge	29.8	16.4	53.8

As presented in table 3, more than sixty percent of the participants in this research agreed with the statement "science and technology are identical." While a good number of the respondents (30.2%) disagreed. That means that most of science teachers in this study held uninformed conception about this issue. At the same time, a majority of the respondents (55.9%) had informed view about scientific enterprise by disagreeing with the statement "scientific enterprise is an individual enterprise." Finally, more than half of the participant teachers (53.8%) thought that society, politics and culture affect the development of scientific knowledge, which represents the informed conception.

4 .4.Sciences Teachers' Informed Conceptions

Table 4. The difference between informed science teachers' conceptions regarding gender

Gender	n	Mean	SD	t-value	*p*
male	42	3.56	0.82	0.03	<0.05
female	41	3.63	0.65		

The majority of science teachers in this study held informed conceptions about five item statements of the NOS. while they had uninformed conceptions about nine item statements. In comparing males and females in this study regarding their informed views about the NOS, it was found that no significant difference was found among males and females ($t = 0.03$, $P < 0.05$). So, this score suggests that males and females were similar in their informed views about NOS (table 4).

5. Discussion

This study indicates that a majority of Saudi science teachers had uninformed views about the roles of hypotheses, theories and laws. An important finding of this study is that teachers were not consistent in expressing their views to a particular NOS aspect and to its associated aspects. For example, a majority of teachers acknowledged the place of imagination and creativity in science, which are regarded as important in developing scientific knowledge, particularly to creating scientific models and designing experiments (Abd-El-Khalick, Bell, & Lederman, 1998; Bell, et al., 2000). However, scientific models were viewed as a copy of reality rather than a product of scientist's creativity and imagination by a majority of teachers in this study. This differs from the findings of previous research (Bell, et al., 2000; Buaraphan & Sung-Ong, 2009; Haidar, 1999). Also, most of the teachers viewed scientific experiments as a universal, fixed step-by-step process; they did not acknowledge the place of creativity and imagination in designing an experiment. Moreover, in this study, science teachers perceived scientists as open-minded and having no biases. This conception held by the teachers may make them resistant to perceive science knowledge as subjective.

As mentioned previously, science teachers in this study believed in the myths of the scientific method and experimentation. They may have these uninformed views about scientific inquiry as a result of the traditional depiction of recipe-like experiments in science textbooks, as textbooks frequently play a crucial role in understanding the process of science (Chiappetta, Fillman, & Sethna, 1991). Like other educational systems (Abd-El-Khalick, et al., 2008), science textbooks in Saudi Arabia portrayed that there is one general method of conducting a scientific investigation (Siddique, 2008). It may therefore be reasonable to argue that science textbooks should be revised on the light of the contemporary conception that there is no particular scientific method to be used in developing scientific knowledge (Abd-El-Khalick & Lederman, 2000b; Abd-El-Khalick, et al., 2008; Bell & Lederman, 2003; Lederman, 2004; McComas, et al., 1998).

A majority of science teachers in this study perceived science as a collective activity. They also thought in the influence of society, politics and culture in the development of scientific knowledge. Although these informed conceptions of scientific enterprise are very positive, many of them held an uninformed view that "technology is the applied science," as previous research suggested (Buaraphan & Sung-Ong, 2009).

6. Conclusion

In this study, it was found that science teachers in Saudi Arabia held uninformed conceptions about many of the NOS aspects included in this research. As in some other educational contexts (McComas, et al., 1998), Saudi science teachers infrequently have the opportunity to learn about the contemporary NOS in their own studies. Learning about NOS should be included in science studies at different levels of education and in different teacher education programs designed for science teachers in Saudi Arabia. The results of this study suggest that further research is required to better understand how Saudi science teachers display NOS in their classes and how the pedagogies of teacher education inform this displaying. As Ogborn (1995) has argued, what is needed as a starting point is a modest and realistic view of the natural sciences, no longer tainted by pretending to fulfill an impossible rationalist dream, and no longer suspect as failing to do so.

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