Chapter 3

EXPLORING THE ROLE OF NATURE OF SCIENCE UNDERSTANDINGS IN DECISION-MAKING

PIPE DREAM OR POSSIBILITY?

Randy L. Bell

INTRODUCTION

> *Were I a traffic cop on the highway of life, I've got to tell you that I'd be very much inclined right now to turn on my flashing red lights, hit the siren, and pull the American Medical Association over for swerving. Now, let's recap just some of the things we've heard from these guys over the last few years: Coffee's bad for you—noooo, coffee's not bad for you. Okay then, alcohol's bad for you—no, alcohol's good for you. As long as its red wine, because the French drink it and they live to be old and problematic despite smoking like chimneys. But wait a minute, check that. It's not just red wine, but any kind of alcohol lessons your chance of stroke, so bottoms up. Unless of course, it's milk. Now that's bad for you. It's got all that fat and stuff in it. But, wait a minute. Everybody's going to get osteoporosis, because they don't get enough calcium. Hmmm... Then, of course Thursday, this story comes out saying the AMA is not so sure all that talk about eating lots of fiber to avoid colon cancer is altogether, well... true. Sorry. Never mind. Somehow, I suspect I'm not the only one who has thoughts of the boy who cried wolf here... After a while, you just stop listening.* (Mike Renfrow, *Morning Edition.* National Public Radio. January 24, 1999.)

Renfrow's dietary dilemma is only one of the many science and technology related issues facing 21st-century citizens. In a world increasingly impacted by the processes and products of science, citizens are asked to make decisions on everything from personal health to public policy. Educators have come to realize that traditional science curriculum with its absolute views does not produce citizens prepared to deal with real-world science, which is more often than not equivocal,

D.L. Zeidler (ed.),
The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education, 63-79.

revisionary, and conflicting. How then do we prepare citizens to make reasoned decisions about scientific issues that are complex and ever changing?

Science education reform documents promote scientific literacy as the answer, of which nature of science is a principle component (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). In fact, recent commentary has specifically linked nature of science instruction to decision-making on science and technology based issues (Carey & Smith, 1993; Collins & Shapin, 1986; Cotham & Smith, 1981; Driver, Leach, Millar & Scott, 1996; Kuhn, Amsel & O'Loughlin, 1989; Lederman, 1983; Lederman, 1999; Millar & Wynne, 1988; Shamos, 1995). By knowing the characteristics of scientific knowledge and the way it is constructed, the argument proceeds, citizens will be better prepared to recognize pseudoscientific claims, distinguish good science from bad, and apply scientific knowledge to their everyday lives.

Given these lofty aspirations for nature of science instruction, it is reasonable to ask what evidence exists to support them. Or, as in so many other instances in science education, are these aspirations based on unfounded assumptions? Are we certain that better understandings of the nature of science would help Renfrow decide how much fiber to include in his diet? Or when it comes to everyday decision-making, does the influence of values, morals, and personal experience wield the greater influence?

In this chapter, I explore the influence of nature of science understandings on decision-making regarding science and technology based issues by summarizing the findings of relevant empirical research and discussing implications of these findings for the classroom. In so doing, I argue for the necessity of explicit instruction on decision-making that emphasizes roles for moral reasoning and understandings of the nature of science.

WHAT IS THE NATURE OF SCIENCE?

A working definition might refer to the nature of science as science epistemology, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development (Lederman, 1992). These characterizations are fairly general, however. When exploring the nature of science construct in more detail, one quickly realizes that those who study the scientific enterprise disagree on some specifics of the nature of science. While this should hardly be surprising given the multifaceted and complex nature of the scientific enterprise, it can be disconcerting to those looking for a quick and easy definition.

Fortunately, the vast majority of disagreements among philosophers, historians, sociologists, and science educators are irrelevant to K-16 instruction (the existence of a reality independent of the observer being a case in point). Furthermore, scholars of the scientific enterprise do agree on many nature of science concepts, and it is these concepts that are most relevant to K-16 science students. For instance, few philosophers, science educators, etc., would reject the idea that scientific observations and investigations are theory-laden, nor would they defend an absolutist view of scientific knowledge. At this level of generality, many critical aspects of the nature of science are noncontroversial. Moreover, these nature of science aspects have been emphasized in recent science education reform documents as being relevant to the development of a citizenry capable of informed decision-making (e.g., AAAS, 1989, 1993; NRC, 1996).

Such concepts include the ideas that scientific knowledge is tentative, empirically based, subjective (theory-laden), partly the product of human inference, imagination, and creativity, and socially and culturally embedded. Other critical aspects of the nature of science relevant to K-16 science instruction include the distinction between observation and inference, the lack of a universal scientific method, and the relationship between scientific theories and laws. For a more detailed description of these aspects and the issue of consensus on a definition for the nature of science, see Bell, (in press) Lederman, Abd-El-Khalick, Bell and Schwartz (2002), and Smith, Lederman, Bell, McComas and Clough (1997).

NATURE OF SCIENCE AND DECISION-MAKING

Considering the importance ascribed to the nature of science in decision-making, it is surprising how little empirical work has been published on it. Besides the work reported in Chapter 3 of this volume, my search produced only three research projects that have explored the nature of science in decision-making, and only one of these has addressed the issue directly. Certainly, more work can and should be done, but even so, these three studies allow for some initial conclusions and implications.

Fleming (1986a) explored the nature of the interaction between high school students' knowledge of the physical and social worlds when making decisions on science and technology based issues. His goals were to identify the domains of reasoning that adolescents use when making decisions and to explore any relationships between the domains.

Fleming chose 38 adolescents who had completed introductory courses in high school chemistry and biology to participate in the study. The students' mean age was 17.3 years. To provide a context for students to discuss their reasoning, Fleming developed two scenarios dealing with nuclear power plants and genetic engineering. These scenarios provided a backdrop for semi-structured interviews that explored each student's decisions, reasoning, and justifications. Fleming subsequently analyzed the interview transcriptions by organizing the justification statements of the participants into categories. Some of these categories were provided by a scoring manual (Davidson, Turiel & Black, 1983), while others were created by Fleming directly from the participants' responses.

The results of this analysis indicated that the primary domain of reasoning for these adolescents lay within the area of social cognition. The two social cognitive domains used by the participants were (a) the moral domain, which emphasizes concepts regarding the welfare and rights of others and justice, and (b) the personal domain, which emphasizes self-preservation, respect for individuality, and control over one's physical state.

Fleming classified 70% of the participants as moral reasoners, with concern for the potential for harm to others as the central reason for the classification. Interestingly, these individuals tended to view uncertainties in scientific data as increasing the risk of harm to others. Therefore, once they perceived potential harm to others in an issue, additional scientific data offered by the researcher were con-

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