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ABSTRACT

Reaching a consensus with regard to fundamental issues involving pluralistic epistemological ideologies entails discourse and argumentation as one attempts to find a fit among his or her beliefs, other individuals' beliefs, and the particular points under consideration. Thus it may be easy to accept the notion of not reaching consensus about anything, including the nature of science (NOS). This paper discusses an examination of the process by which views and related concerns about NOS were addressed at the 1996 Annual Meeting of the National Association for Research in Science Teaching (NARST). The premise was that an examination of the process by which experts exchange ideas with each other and the greater science education community would provide indicators of how the same issues might be addressed in science education courses. Some questions considered were: 1) What is the context of the NOS forum, and how does this setting interact with the focus group discussions? 2) Are there salient issues brought out during the focus group discussions which may contribute to science education course design? And 3) What is the status of "consensus" with regard to the feasibility/necessity for consensus of an agreed-upon conception of NOS for science education? The data sources for this inquiry were: (1) tape recordings of general and small group discussions; (2) field notes from sessions; (3) abstracts and full length papers presented; (4) summary overhead transparencies from the "wrap up" of the session; and (5) follow-up open-ended questions sent to presenters. (PVD)

Assessing Views on the Nature of Science: Reflections from Oz

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Assessing Views on the Nature of Science: Reflections from Oz

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Introduction

In L. Francis Baum's (1899) book, "The Wizard of Oz", Dorothy, the Scarecrow, Lion, and Tinman, each visit the Wizard separately. When they come back together to discuss their experiences, they each describe a "different" Wizard. Perhaps that was the nature of the Wizard; to transform himself into whatever his visitors wanted to see. The experiences of the Oz characters reminds us of the experiences of those who participated in the "Reaching Consensus on the Nature of Science" session at the 1996 NARST Annual Meeting. What we come to understand and believe is filtered through our prior idiosyncratic experiences. Accepting that premise, it may be easy to accept the notion of not reaching consensus about anything, never mind something as encompassing as the Nature of Science (NOS). Nonetheless, some degree of shared social knowledge serves as a base on which new knowledge, governed by our unique experiences, generates new knowledge.

Can such an encompassing domain as science with a vast background and diverse players possibly reach consensus about the nature of science? Is it necessary or desirable? Alters (1997) points out that there exists a "myriad" of NOS tenets in the science education literature. Moreover, philosophers of science also vary in their views pertaining to the basic NOS tenets. Perhaps by examining the process of how experts exchange ideas with each other and the

greater science education community will provide indicators of how we may possibly address the same issues in our own science education courses. The intention of this paper is to examine the process by which views and related concerns of the NOS were addressed at the 1996 NARST conference. This setting served as the Association's land of Oz. Perhaps many of us journeyed to this session hoping to face the (NOS) wizard. And again the wizard transformed itself into something different for each of us. No matter. It is the authors' contention that each of us can still benefit in our own classrooms by becoming cognizant of key issues that were raised at this session. We readily acknowledge that the process of raising issues was, in part, shaped by the logistical arrangements (multiple simultaneous discussions in a "jig-saw focus group") broad paper themes, and varying levels of familiarity with those papers by members of the audience. The assumption was that those who attended this session had previewed the papers on the NARST list-serve - which was not the case. The authors also wish to express their grateful appreciation to those presenters of the 1996 session for their willingness to permit us to review their presentations and providing us with insightful comments relative to those sessions.

Approach

To investigate how views of the NOS are exchanged in a social context of a professional meeting, an informal naturalistic approach was used. It was informal in the sense that a long period of immersion into the culture of the conference session was moot, and the level of thick description was limited to three concurrent sessions that lasted about 90 minutes. Hence issues of transferability to other NARST contexts seems nonsensical. In contrast, if a methodology was used that allowed for diversity of data and individual interpretations, then "samples of thought" could be culled from this session with the aim of helping science educators be sensitive to the challenges, opportunities and potential pitfalls surrounding the NOS in the courses they teach.

The focus of the inquiry (which was open to change as the data was collected and examined) became: 1) What is the context of the NOS forum and how does this setting interact with the focus group discussions? 2) Are there salient issues brought out during the focus group discussions of the NOS by members of NARST which may contribute to science education course design? 3) What is the status of "consensus" as to the feasibility/necessity for consensus of an agreed upon conception of the NOS for science education? 4) Having presented papers and engaged in group discussions, what is the nature of the authors' reflections concerning their topic several weeks after the forum?

The data sources for this inquiry included the following: 1) Tape recordings (later transcribed resulting in 32 single-spaced pages of dialogue) for the general and small group discussions; 2) Field notes collected by observers at the sessions; 3) Abstracts of papers presented; 4) Full length papers presented; 5) Summary overhead transparencies used at the "wrap up" of the session; 6) Follow-up open-ended questions sent to presenters several weeks after the conference.

(1) What is the context of the NOS forum and how does this setting interact with the focus group discussions?

The following provides a brief description of the NOS session at the 1996 conference. The purpose of this description is to provide the reader with some degree of tacit knowledge for the context of the focus groups. The notes are based on a synthesis of the three focus group discussions occurring simultaneously and represent selected instances of factors related to the context of the presentation. The letters "O.C." represent observer comments that were made at the time of the session or upon reflection of the session. They are offered as pedagogical points to bear in mind in the development or teaching of science education courses that contain issues related to the NOS.

The conference room is large but because of a large turnout for this session it is clear that the participants will be somewhat cramped when this forum breaks down for three separate small group discussions. The audience

gathers chairs and move toward a corner of the room to hear one of three speakers summaries. It is a bit chaotic as this rather large group attempts to moves chairs that were in uniform rows into a cluster of concentric circles. Everyone is pretty much sitting shoulder to shoulder with each other, attempting to squeeze in close enough to hear the speaker. Each of the three focus groups has between 25 and 40 participants. Papers are passed around but there are not nearly enough to provide each participant with his or her own copy. Some presenters assumed the audience would be able to view overhead transparencies for each presentation so it would not be necessary to provide all with the paper. However, the last minute changes in how the focus group would operate rendered this option useless. [**O.C.** Given the abstract and esoteric nature of some of the papers, it will no doubt be difficult for a participant to keep the salient points in mind and not "shoot from the hip" when it comes time to engage in dialogue]

Each speaker presents an overview of the salient points for his or her paper. Some do not read or look at their paper as they appear to be very comfortable with the content contained within it. Those who have their own copies of the paper are scanning it as the speaker talks. At any given time, between 5 to 7 audience members are jotting down notes. Other presenters read extended portions of their paper (because of the technical content and lack of overheads provided for them) and spend about 15 to 20 minutes presenting their major points. There has been no interaction from the participants at this point in time. The speaker summarizes his position in a little over five minutes. This summary lasts about 5 minutes. Most of the participants appear to be carefully listening to the presentation so far.

I can hear quite distinctly a second speaker in another group directly behind us. His voice carries and does interfere with what the other two focus group speakers are saying. It is distracting. To a lesser extent, I can hear the speaker from the third group. There is laughter from both other groups periodically as there has been more interaction sooner from the participants in other groups. [**O.C.** The "spill-over dialogue from the other groups is quite

distracting.] The speakers finish with their presentations and the "group" discussion begins. In one group, an audience member states confusion about the concept of constructivism. Another member of the audience refines their epistemological position on constructivism in a reflective manner. [**O.C.** The comment appears to be well thought out and clearly articulated, (the explanation lasts about one minute) but it is a level of abstraction clearly beyond the person who initially stated their confusion. This participant restates their confusion again about constructivism and asks the same individual to restate it. However, a different audience member intervenes and summarizes this particular view again in only a few words (this explanation takes about 5 seconds). This restatement can not do justice to the previous lengthy articulation of this concept. However, the confused participant appears to be satisfied.

No unification of concepts discussed by several presenters in a group concerning the NOS occurred until the last few minutes when one individual attempts to seek a synthesis among the three papers that were presented. It is interesting to note that this person is a member of the audience. It is as if the audience is seeking cohesion with respect to the topic, but it is not being provided by the presenters. This may be by design or the session may have just progressed this way. Regardless, there has been no effort on the part of the presenters to attempt to "pull together" the groups discussion or poll the audience as to their positions relative to the NOS.]

As the audience members rotate to hear new speakers ("jig-saw sessions), the speakers energy levels appear to kick into a higher gear. The presenters seem to be somewhat more dynamic this time and the talk seems more focused. More direct audience contact seems to be made with less reading of papers. [**O.C.** Three or four people in a given group are actively taking notes while most everyone appears to be listening intently and periodically nodding as if to suggest "I agree with your point or I at least follow the point being communicated". This group seems more willing than the first group to be persistent in their comments and questions and allow for

varied definitions of the nature of science. Perhaps the "strangeness" of a session like this is wearing off and they are therefore more inclined to participate and advance their own ideas concerning the nature of science. One individual from the audience seems to be taking "center stage" at this point. He appears less interested in developing a line of discussion as he is in hearing the sound of his own voice. This audience member takes this opportunity to discuss his students research. I'm wondering about the relevance of his comments to the NOS discussion. Four or five people become engaged at this point and discussion lasts about 5 minutes. The remainder of the group (20 or so people) seem to be disengaged as they do not appear to be attending to the speaker. While time has run out most participants seem eager to continue their group discussions. I overhear that no consensus has been reached for some while at least one individual states: "I don't agree that there is no consensus".]

The audience seems keenly interested in the summary of the sessions. [**O.C.** Perhaps a sense of closure for the session (not the necessarily the topics discussed) is needed]. The following are the summary overheads from the end of the session (again, note the conflicting statements in consensus among the three groups:

Group 1 Overview

- Context vs. nature of science: priorities???
- Is there agreement about what constitutes western science?
- Is it really important to distinguish science from non-science?
- Do we need to reach consensus?

NO CONSENSUS... and, within which groups is this the case?

NO Agreement even on empirical necessity.

Reasonable???

1) Elementary teachers must be provided with enough information to develop a view on NOS.

2) A good operational definition for elementary teachers "Nature of science is the process used in scientific inquiry and the developmental and testable nature of the knowledge."

Group 2 Overview

1) Certain "lenses" are needed for different learning and different questions.

2) To label something non-science does not make it frivolous and silly.

3) Science educators agree more than disagree about NOS.

Group 3 Overview

- Definition of science....is it needed?
- Benchmarks has a definition...so lets use that definition (or not).
-N.A.S. "we have a definition of science" let's use it (or not).
-Do we know what technology is?
- Who or what counts as scientists?
- Not much agreement was reached about the NOS

(2) Are there salient issues brought out during the focus group discussions of the NOS by members of NARST which may contribute to science education course design?

It may be instructive to those of us who wish to include the NOS and related aspects in the various science education courses that we plan to design or currently teach to examine the discourse of NARST members as issues arise during the focus groups. The following represent samples of thought from those discussions followed [parenthetically] by pedagogical implications for classroom practice. At the present time, they are not organized thematically, and nothing is suggested as to their relative importance by their order. For the present time, each discussion may be viewed as a starting point to address similar issues with our students. This analysis will present five issues that would appear to have significant educational implications for science education courses dealing with this topic. The page numbers which appear in [brackets] are for the authors' reference and are keyed to page and line numbers of the transcripts and may be ignored by the reader.

Issue 1) "...we assumed that understanding the nature of science requires a distinguishing between science and technology. Both the national standards and the national benchmarks call for that as one of the goals in that area. We also observed that many lab activities, lab manuals, and teachers' guides blur this distinction. ... We also observe that teachers use the word "technology" in two ways. They'll say, 'Oh, yes, we use technology in our schools,' but they're referring to computers and A/V equipment and so forth. Otherwise they'll be referring to engineering design technology. You never know which one they're talking about until you really unpack the conversation to figure that out. There's a lot of danger for miscommunication because of that." [p2.20.32]

[The importance of definition in language and the role of context in understanding language in general, or shifts in the use of everyday and scientific language in particular is an important consideration in our classroom. The emphasis in common language is important because of how it may impact our understanding of the NOS, especially when there is inconsistency in the use of a definition, term or concept. Teachers' language has been shown to influence students conceptions of the nature of science (Zeidler and Lederman, 1989). Shifts in language, from scientific or technological contexts to everyday contexts without forethought misleads students and develops naive understandings of the subject-matter at hand. Talking about scientific knowledge and concepts requires a distinction between that knowledge (knowledge about the natural world) and knowledge about science (which refers to the entities of science itself -theory, law, observation, inference, etc.) Driver, Leach, Millar and Scott, 1996) This distinction is often lost in classroom discussion related to the NOS.]

Issue 2) "As far as things to recognize, in science, we focus on reproducibility. It's supposed to be reproducible within certain ranges, An experiment or a proposed theory should be seen again and again in a variety of contexts." [p3.37]

[A cautionary note is in order here. While we do focus on reproducibility in science, particularly in quantitative contexts, we also focus on "transferability"

when the context warrants qualitative investigations (Lincoln and Guba, 1985). Science educators need to consider the notion of experimentation, inquiry and their relationship to the generation of scientific theories.]

Issue 3) Person A. "Someone I was with at a meeting a few days ago said that there had been a three million dollar grant to bring constructivism to the classrooms. Let's just bring thinking to the classrooms."

Person B. "When do we put the labels of realism and relativism and constructivism and absolutism on ideas of children? ... Or do we put handles on it?"

Person C. "When they're doctoral students."

Person A. "One of the things that troubles me about the way the word constructivism is being used, I think your example is one to describe how people learn. I don't think it's good to convey an epistemological stance. I think there's a lot of confusion. One does not 'embrace' or 'not embrace' constructivism as a theory about how people learn. We think everybody's a Constructivist. I think the whole sense that it's a choice becomes an epistemological position. I'm not sure schools are the right place to be choosing an epistemological position. I think this question is clearly an important one to distinguish constructivism as pedagogy and constructivism as epistemology. These are often run together. ... Theories of knowledge and theories of instruction can be separated. Going back to Plato, Plato was a Constructivist in epistemology. His Socratic dialogues are the epitome of constructivism. Yet Plato's epistemology was absolutely nonconstructivist, which was tied perhaps to some of the more endearing and wonderful constructivist teaching practices. This distinction is often made as it should be and some people think that to be a Constructivist in pedagogy, you have to be a relativist, embrace the position that all positions are good. You may or may not." [p.4.30.15]

[As with number one (above), teaching about the NOS not only entails a vocabulary that may be used differently in different contexts, but simultaneously entails both having to think about pedagogy, and about

epistemology. Constructivism serves just one example of the "naturalistic fallacy" - which leads to a blurring of lines among philosophy, psychology and classroom practices.]

Issue 4. Person A. "I think those examples bring up the difficulty in demarking science from other areas. Once you draw a definition of science that is broad enough to include what most of us consider to be legitimate science, you know, have a definition that's so broad, you find it difficult to keep other things out. So the question comes back to me, why are we trying to do this anyway? What is the purpose of trying to draw this clear, distinctive boundary so we can always say, 'This is science this is not'? It seems to me that it typically comes back to political issues, that you try to keep certain things out. ... Holding up the barricade, to me, doesn't seem to be the appropriate stance, whereas clarifying what you do, trying to understand the objections of other people might be a more appropriate approach."[p.25.5]

Person B. "Can I follow up on that? I think that's a very important thing to think about. Why are we asking the questions that we're asking? This question of science/nonscience is a particularly interesting one. Also the question of the symposium is, can we reach a consensus on the nature of science? I guess my question is why do we want to do that? Is it that we feel like we have to have a consensus before we can teach something? Do we have to have a capital letter T: true that we can feel certain about it before we can engage students in conversations about it. Maybe take that a step further, suppose we did reach a consensus, what difference would that make?"[p25.16]

[The ideas stemming from this exchange seem to fall into the notion of what constitutes fringe, preparadigm, and normal science and how a particular ontological, epistemological or methodological position gains or looses favor with a given practicing community of scientists. While many science educators would assent to the claim that we do not need a "capital letter T" before we engage students in conversation about the NOS, many preservice teachers, as with people in general, do not fare well in tolerating ambiguity (Chinn & Brewer, 1993). Developing tolerance for multiple views of science

in our students is difficult when most students view this as a mixed message which they find intolerable. It is probably not the case that simply telling students that a scientific attitude entails tolerating ambiguity will placate them and eventually lead them to viewing science from an array of perspectives (Zeidler, 1997).]

Issue 5) "When [the previous speaker] talks about pluralism and epistemologies, I want to take that even a step further and talk about pluralism of epistemologies within science. So I'm talking about the nature of science as not the nature of science, but natures of science. ... [For example] on one side we have biology, the study of life sciences, and on the other we have physical science. Under biology on this side, we have ultimate causation. By that I mean that there are sciences and there are times in sciences when you need to think about ultimate causation, the causation that comes from the evolutionary history of , in most cases, organisms that you're speaking about. On the other side under physical science, is proximate causation. Almost all of chemistry, a lot of physics, deals with proximate causation, things that happen immediately, cause and effect. ... Another example, to me it's cold in this room. Maybe just because I'm nervous. But I have goosebumps on my arms right now. Now the proximate cause of my goosebumps is that I feel cold or nervous. But the ultimate cause is that through evolution, I have an adaptation which allows the hairs on my arms to be raised, which causes an insulation. ... The ultimate cause of my hair raising is rooted in evolution. The proximate cause is that it's cold in the room.

Another [dichotomy] is descriptive and comparative science. I put that under biology and ultimate causation. I've heard in the past and even today in another session that things are just descriptive and comparative. And what we're really going for is experimentation. I have a big problem with that. There are many important questions in science that are simply not available to experimentation. If you look at many sciences like geology, paleontology, ecology, astronomy, these are not experimental sciences. They are legitimate sciences with their own journals, the whole thing. But they're not

experimental. I'd like to call attention to the fact that I don't think that we pay enough attention to comparative and descriptive methods when you talk about the nature of science. If you look at any science text book, you'll see that science is always defined as experimental. Never as any other way.

To sum up, I think that in science education, what we tend to do is focus on this side of the dichotomy over here - physical, proximate causation, experimental science, cellular and molecular biology, or reductionism. We focus a lot of what we teach and a lot of what we do, and if you look at the history and philosophy of science in general, what you'll read is the history and philosophy of physics. Not the history and philosophy of biology. What I'd like to do is say again that as we think more about the nature of science as maybe being on this side [postpositivistic/holistic paradigms] as well. There are multiple natures of science. I think this side needs more place in the classroom." [p.21.14.45]

[In this lengthy but instructive example, the speaker conveys a crucial message along with explicit and implicit caveats) to those science educators confronting a new generation of science teachers. The caveats arise because of a Catch-22: the sense of epistemological pluralism that we confront students with stands in stark contrast with the dominant positivistic view of science that students have been exposed to in most of their previous science courses. The speaker makes it clear that there exists natures of science, and that some forms of knowledge may be more suitable in different situations. It has been noted (Zeidler, 1997, Cerbin, 1988) that both high school and higher education often produce students who are discipline-bound because instruction in science classes fails to make clear that what counts as legitimate support for scientific theories or arguments differs across disciplines (e.g. statistical data, case studies, exemplars, principles, theory, authority, interviews, historical evidence personal narrative, etc.) Furthermore, what qualifies as acceptable evidence and what science content students have had exposure to often arises from disciplines that do not view themselves as descriptive or comparative (Lederman, 1996). This is compounded by the observation that most scientists

who teach science are unaware about issues related to the NOS (Pitt, 1990; Pomeroy, 1993). Science educators need to arm themselves with this realization as they proceed to design and implement courses which entail aspects of the NOS.]

(3) What is the status of "consensus" as to the feasibility/necessity for consensus of an agreed upon conception of the NOS for science education?

It was evident from the overviews of the focus groups found in section one above, and from portions of the transcripts, the most audience members of NARST (in at least two of the three groups) were reluctant to agree on common single agreed conception of the nature of science. Five of the presenters (designated as a,b,c,d and e) that helped run the three focus groups, held varying opinions at to the feasibility or necessity for achieving consensus. A summary of their personal reflections follows:

[a]

- Reaching consensus is an attainable goal ... otherwise we are demonstrating our shortcomings as a community.
- need a taxonomy of science educator's epistemologies.
- On a logical level, consensus is completely necessary.

[b]

- Most participants find it easier to give a blanket "no" instead of attempting to find specific ideas we do agree upon.
- agreement could be reached on a general level (at least for k-12); esoteric points of disagreement not relevant for k-12).

[c]

- If scientists can arrive at consensus on foundation issues, surely science educators can too.
- Consider the consensus-like documents (AAAS) and consider where we agree, not just where we disagree.

[d]

- No agreement reached; a wider range of possibilities may have been the result.

[e]

- Participants concentrated on unique areas of difference; not areas of similarity.
- Papers were not interrelated so no one was forced to deal with similar aspects of science.
- Postmodernism's effect on science will probably keep agreement at bay; Much methodology can stand without reductionist camps behind them (either/or approach)

It is interesting to note that on one hand, the notion of reaching consensus on the NOS seemed to become a less attainable goal after this particular session. This is not to imply that there was an a priori expectation that it should happen; only an observation that from the presenters perspective it did not. Our interpretation from the language of these laments is that with a more narrow and focused discussion, the presenter would indeed expect some consensus on at least foundational issues related to the NOS (e.g. the tentativeness of science, the creative aspect of science, the acceptance of multiple methodologies reflecting different paradigms of science, and the like). However, most audience members were reluctant to commit to any level of epistemological consensus on the NOS. Inferring from the "tone" of these comments, this may reflect a level of entrenchment in one view of science on the audience members' part. But such levels of skepticism are no doubt an asset in science education, as long as that skepticism does not serve as a cognitive filter that taints new ideas too quickly. If that is the case, healthy skepticism becomes blurred with dogmatism - certainly a pitfall to those in a position to examine such issues in their classes.

(4) Having presented papers and engaged in group discussions, what is the nature of the authors' reflections concerning their topic several weeks after the forum?

As in number three above, Five of the presenters (designated as a,b,c,d and e) that helped run the three focus groups considered their own positions

and thoughts several weeks after their interaction with other NARST members. Once again, a summary of their personal reflections follows:

[a]

- Have acknowledged conflicting positions with paper.
- Added additional arguments to paper.

[b]

- Amazed that groups were hesitant to reach any agreement whatsoever, even on fundamental points. Points out that participants no doubt went back to their methods classes and told their students how to teach the nature of science.

[c]

- The "value and lived experience" of the session varied greatly from participant to participant. Although important ideas were considered, holistic consideration, analysis and synthesis probably did not occur for most in attendance.

[d] Own points have not changed; noted a lack of research to support various participants positions.

[e] Those who attend to Multiculturalism in science emphasize diversity to the point of appearing as separatists, rather than discussing all the similarities; what is common to students should be in allowing them to determine when to apply scientific knowledge and when not to in constructing their own meaning of the world.

These thoughts reflect similar sentiments as three (above). It strikes one presenter as odd that while no consensus was reached even on fundamental issues (in his/her group) that participants would probably return to their methods classes and tell theirs students how to teach the NOS. For some, the dialogic interaction among audience members revealed inconsistencies in their initial papers which were later modified. For others, their positions were derived from research and were not altered by epistemological positions of the audience. Still, other presenters were sensitive to the fact that audience members came from varied epistemological

traditions and were reluctant to depart from those positions and seek common ground. It may be the case that it is unreasonable to expect that degree of conceptual shift within the allotted time frame. All felt, however that while a synthesis of ideas did not occur at the session, ideas exchanged at the session prompted each to consider their positions relative to views brought to light during the discussions.

Final Thoughts

Reaching consensus about fundamental issues involving pluralistic epistemological ideologies entails discourse and argumentation as one attempts to find a fit among his or her beliefs, other individuals' beliefs, and the particular points under consideration. Duschl and Gitomer's (1991) presentation of Laudan's (1984) reticulated view of theory change may serve to shed light on our expectations of seeking conceptual shifts - whether it be in a conference session or our classrooms. This view holds that change (theory or conceptual) does not necessarily happen in incremental linear steps; rather mutual factors (other's perspectives) continually restructure, alter or fine tune a person's goals, procedures, and personal knowledge. Laudan's reticulated model for partial conceptual change allows for modifications to either one's ontological, methodological or axiological commitments. (Note that this model stands in contrast to Kuhn's view of a paradigm shift in which theory change (core beliefs) would correspond to a change in *all* ontological, methodological and axiological commitments.) This notion is particularly important in light of student discourse where one person's beliefs and evidence may be incongruous (anomalous) with those of another. Teachers need to realize that students will find ways to protect their prior beliefs against the positions held by others that are dissonant. Change of epistemological stances, if it does occur, will probably happen only piecemeal and slowly over time.

The above issues that were revealed as experts in the field of science education discussed the NOS help us to understand the problems associated with peoples' reactions to such discourse. It would behoove science educators

to consider such issues as they develop and teach various courses with NOS-related themes. The issues that were constructed from this inductive case study approach serve as indicators of the difficulty we face when examining the language of science and the nature(s) of science relative to science education. Remember, in the land of Oz, the visitors were allowed to determine which issues were relevant in constructing their own meaning of the wizard and the world.

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