Using Internet on the Way of Scientific Literacy

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In recent education reform policies of different countries, scientific literacy was set as the national goal for science education. Understanding how science itself and scientists really work, in other words, understanding the nature of science is necessary to reach the desired scientific literacy level. Students also need to understand the components of nature of science such as scientific inquiry to reach that literacy level. Importance of understanding the nature of science with all components was explained by the prior research studies as follows.

Understanding the nature of science enhances.

- the learning of science content
- the understanding of science
- interest in science
- instructional delivery (Mc Comas et al., 1998)

The nature of science is also a useful tool to change teachers' views of learning and teaching. Brickhouse (1989) argues that how teachers perceive teaching and learning and how they really teach are influenced with their understanding of the nature of science. Specific instructional behaviors, activities, and decisions implemented within the context of a lesson are the most important variables that influence students' understanding of the nature of science. Therefore, teachers themselves need to have adequate understanding of the nature of science.

In this research study scientific literacy, nature of science and scientific inquiry were defined as follows.

Scientific literacy

Although there are different definitions of scientific literacy, Mayer's (1997) definition is used in this study.

Mayer (1997) argues that scientific literacy is dependent upon specific amounts of science content knowledge. Mayer (1997) defines scientific literacy as the knowledge of substantive content of science that is related specifically to understanding the interrelationships among people and how their activities influence the world around them. Driver (1996) defines the dimensions of scientific literacy as

- Science content: understanding facts, laws, concepts and theories.
- Scientific inquiry: Understanding of the scientific approach to inquiry. The ability to define scientific study and to discriminate science and non-science.
- Social enterprise: understanding science as a social enterprise.

Nature of science

According to Lederman and Zeidler (1987) nature of science most commonly refers to the values and assumptions inherent to the development of scientific knowledge (Lederman & Zeidler, 1987, p. 721). Lederman and Zeidler (1987) identified these values and assumptions with Rubba's (1977) six categories of nature of scientific knowledge explained in his nature of scientific knowledge scale. According to these categories, scientific knowledge is amoral, creative, developmental, parsimonious, testable and unified. An individual's beliefs about how scientific knowledge fits into these categories, reflect his/her understanding of nature of science.

There are also other definitions of nature science as follows

- The processes of scientific inquiry and the developmental nature of knowledge acquisition in science depict the nature of science (Klopfer, 1969)
- Science is tentative, public, replicable, probabilistic, humanistic, historic, unique, holistic, and empirical (Schowalter, 1974).
- Science is tentative and revisionary (Cotham & Smith, 1981) as reviewed by Meichtry (1993).

In conclusion; understanding the nature of science consists of an explicit understanding of how knowledge claims are produced, checked and validated. It also consists of understanding how scientific knowledge is socially and culturally embedded and how it is influenced with the social commitments and values on the choices and interpretations that scientists make (Driver, 1996).

Scientific Inquiry

Duschl (1990) defines nature of science as two faced; products of science and processes of science. Products of science refer to knowledge claims generated throughout history, such as facts, principles, concepts, theories, and laws. Whereas processes of science refer to the methods used to make these knowledge claims. Within this framework, scientific inquiry is one knowledge construction method (Duschl, 1990). Being a knowledge construction and validation method, scientific inquiry is a connection between an individual's understandings of the nature of science and scientific literacy (Meichtry, 1993). According to Klopfer (1969) and Duschl (1990) when individuals understand the developmental nature of science, which suggests that scientific knowledge is never proven in an absolute and final sense and changes over time, it may be easier for them to accept reformulation of scientific ideas. Given this, scientific inquiry as a way of generating new knowledge claims may help individuals to reformulate these ideas. Based on these definitions, pre-service elementary teachers' understanding about nature of science and scientific inquiry is elaborated by using the relationship between technology use and scientific literacy.

METHODS

A cohort of 24 pre-service elementary teachers enrolled in elementary science methods course at a large North-eastern University served as research participants. Most were traditional students in their last semester of coursework prior to student teaching.

This study examines pre-service elementary teachers' understandings of the nature of science-scientific inquiry and its role in school science via document analysis. These documents are student-generated artifacts, which are the natural outcomes of science education methods course (Scied 458) assignments. Given that data sources are classroom assignments, it is necessary to introduce the context of the methods course.

Science Education Faculty and graduate students designed the methods course "Teaching Science in the Elementary School" (Scied 458). The course is thought concurrently with mathematics and social studies methods courses and a middle level field experience. Since the course was developed from the research and practice of past and present professors, graduate students, and undergraduate students involved in the improvement of science education in elementary schools, it has been and continues to be a work in progress. Course instruction was based on a conceptual change approach to teaching science and lessons designed using the Generative Learning Model was used as exemplars.

Following research questions are examined

1. What are pre-service elementary teachers' understandings of scientific inquiry?
2. What are pre-service elementary teachers' understandings of the "place" of scientific inquiry in school science?
3. What are pre-service elementary teachers' understandings of the roles and responsibilities of the teachers and students within an inquiry based science-learning environment?

Although multiple sources of data were collected throughout the course of the semester, only Connecting Communities of Learners, CCL, dialog journal in which technology is used to collect data was mentioned in this article. CCL dialog journal is a class assignment used as data source to obtain evidence of what participants know about scientific inquiry and how scientific inquiry might be used in an elementary science class as a way of teaching. Dialog journal is an electronic forum, which consists of a classroom vignette "Willie the Hamster" from "National Science Education standards Science as inquiry" content standards (NRC, 1996, pp. 124-125). An inquiry based science lesson takes place in the vignette. The questions proceeding "Willie the Hamster" were used to understand participants' perception about the most effective and problematic aspects of scientific inquiry approach displayed in vignette. Initiative discussion questions were

Please react to Mrs. Watson's (teacher in the vignette) approach with her students.

- What is the most effective aspect of her approach? Why?
- What is the most problematic aspect of her approach? Why?

These questions were formed by researcher and the course instructors with the intend to understand participants' understandings about scientific inquiry and how inquiry approach to teaching and learning might be used in an elementary science class. Following CCL dialogs a post philosophy statement, which includes questions such as "what is science to you?, what is your past experience with science?, what are the roles of teachers and students in a good science learning classroom?", given to participants to elaborate their understanding about scientific inquiry. Since the research is qualitative in nature, open coding is used to analyze data. CCL journals were examined individually and open coded. The researcher marked the major idea brought

out the paragraph and wrote down related concepts emerged in each paragraph. Then concepts were combined to form categories and categories were named next, CCL journals were compared across research participants. Repeated patterns for categories were noted. Assertions were generated and included exemplar quotes.

FINDINGS

Assertions related to each research question were formed and listed as follows.

-Participant understandings about scientific inquiry.

Assertion 1. Participants identified scientific inquiry as the means by which new products or facts are "discovered" and added to the body of scientific knowledge.

The following quote illustrates this trend.

In the past, I had seen science as a collection of knowledge that someone else had discovered and that others were to "learn". Science, however, is not just the knowledge that someone else knows, it is the process of examining and finding out about our world that lead us towards discovering these explanations on our own. It is also the process that allows us to challenge the findings of others and expand on the ideas of others. It is a way of coming, on our own; through discovery and exploration, to an understanding of how things work. In it's essence, science is problem solving. It is the answer to the questions, and the process of finding that answer. Furthermore it is the refusal to accept that answer as truth and to challenge and test it further. That is why the "content" of science is always changing; because scientists are constantly challenging and expanding their ways of understanding…It is seen as an unchangeable truth that students are to absorb. Instead, students must come to see the ever-changing nature of science and their own abilities to be scientists. (Post-P, 2)

Science was not only perceived as a collection of facts but also a process that scientists and science students used to construct new knowledge claims.

-Participants' understanding about the place of scientific inquiry in school science

Assertion 2:

Participants explained that school science should reflect scientists' work, which they described in terms of scientific inquiry.

The following quote illustrates this emphasis.

Inquiry is a natural component of any lesson. I define inquiry as the questioning and discovery of a topic…When children are challenged and encouraged to learn and make connections, inquiry occurs simultaneously. It is not something that can be taught specifically. It should be incorporated naturally, as a part of every lesson because it encourages children to want to learn…I will begin most of my lessons with some sort of question, problem or aspect of discovery. This will initiate the inquiry process. Students will be stimulated to think and examine the topic. They will want to explore it because there is a definite purpose. This was a way in which I began my science unit. I focused on the topic of reflection and how they might differ. I then followed up with hands-on experimentation, which led to minds-on connections. The whole process was centred around inquiry. It was a natural component of my lesson. Inquiry also directly relates to my interpretations of the nature of science. Students must be encouraged to inquire about the world. If they are taught to think and question, inquiry is incorporated (Post-p., 7)

According to this participant inquiry is the natural result of making meaning of what was learned. Meaningful learning, which requires student to be engaged in hands- on and minds- on science activities, is centered on scientific inquiry.

-Participants' understanding about the roles and responsibilities of teachers and students within on inquiry based science-learning environments.

Assertion 3:

Participants described science learning as very activity-oriented, emphasizing physical engagement via hands-on experiences as the primary approach for learning science. They also identified scientific inquiry as a means to engage students intellectually as well as physically in learning science.

The following quote exemplifies this activity-based orientation

Using inquiry is very important to use in the science classroom because it helps us to think more deeply about areas we are exploring. For example, in class [Scied 458] we were to determine which objects would sink and which would float in a tub of water. We made our predictions, but if no further inquiry was done, we would have never discovered why the objects did or did not float. This inquiry was necessary for us to question the phenomena, which was occurring. This is a part of doing science inside of school as well as outside of school, but more often at home we skip the inquiry and take less time to reach our conclusions. This may present misconceptions and this is why children need to explore through inquiry in school so they can apply the process

in other situations…In order to teach for understanding I plan to use guided inquiry approach. ..For example, if students are learning about sink and float, I may ask them if they can do anything to make a material float which would normally sink such as aluminum foil if they were not making a connection with how air aids in floatation…(Post-p., 4)

The quote represents participants developing understanding of the role of inquiry in science learning

Assertion 4:

Participants perceived teachers as facilitators rather than knowledge distributors. They used examples specific to a guided inquiry approach.

Participants' reflections on the most effective and problematic aspects of the teachers' use of scientific inquiry as a means of facilitating student learning illustrate how they perceive teachers role. The following quotes are representatives of pre-service teachers' thinking about this task.

I believe the teacher's most effective aspect of her approach was to allow the students to experiment with their ideas of why the water disappeared. Although she knew the hamster did not drink the water, she allowed the children to explore and discover this for themselves. The children did a lot of work just to find out the hamster was not drinking the water, but they also learned a lot from it. Being wrong plunged them into thinking further. They used their prior knowledge to get ideas. E.g., Patrick knew how his mother dried wet laundry. They then had a chance to try out other ideas until they found an answer that worked. (CCL, group 4)

As illustrated in the quote above, scientific inquiry complements pre-service teachers' notions of what students should be doing in terms of taking responsibility of their own learning and how teachers should help them be successful in this process.

The following quote reflects a similar perception in a more detailed way:

I thought Mrs. Watson's approach was a great way to gain the students interest and get them excited about learning about evaporation. She used something that related to their lives and their classroom and she allowed them to discover answers to their questions about the watering can and Willie. When the students thought they had figured out what had happened to the water, and she knew that their conclusion was not correct, she did not tell them they were wrong, or tell them what had happened to the water, but probed them to defend their ideas. She used productive questions to help them convince her of what they had done. …To guide them even more, she gave them further experience but did not present them with "the answers". (CCL, group 1)

Acting as a facilitator in inquiry-centered learning situations means to create the environment in which investigations take place. Teachers introduce conceptual knowledge, mathematical and technical tools, and general guidelines at optimal moments. They also need to select learning experiences and adapt and design curricula to meet the interests, knowledge, abilities, and backgrounds of their students. The teacher also ensures that students communicate to each other; reflect and build on one another's ideas, demand evidence to support opinions, assist each other in drawing conclusions, and challenge the facts, assumptions and arguments underlying different points of views (Layn, 1996, pp. 38-39).

Although science methods course helped pre-service teachers elaborate on how teachers facilitate science learning, they still continue to struggle with reconciling the traditional role of the teacher with their developing understanding of teaching and learning science in a manner consistent with contemporary reform efforts.

Additionally, open coded analysis of CCL journals also brought out their understandings about research questions and a new category emerged. The new category and related concepts were listed in the Assertion 5.

Assertion 5.

Potential barriers in science teaching with scientific inquiry are lack of effective and consistent models in field experiences, assessment and time.

-Lack of effective and consistent models in field experiences

Participants tended to blame on cooperative teachers and elementary students for the situations, which did not allow them to use inquiry in science teaching. The following excerpts illustrate this point.

For our science lessons I think it is important to have a hands-on and minds-on lessons. However, I am a little nervous about doing this because I have not seen practically any learning or teaching take place in my class, my teacher likes to stay behind his desk and joke around all day. As you can gather, the students don't really think about why's too often in my class. I am not really sure how to incorporate all these hands-on minds-on components when my students aren't used to thinking this way. (CCL, group 1)

Due to their limited repertoire of strategies for dealing with classroom issues, there is a lack of self-confidence for pre-service teachers.

-Assessment

Participants raised issues about ways of assessing science learning as illustrated in the following quote.

What I found problematic was how the teacher knew if the entire class understood what happened to the water. Patrick came into his own conclusions based on his mother's laundry, but what about the other children? I wonder if they had any idea as to what happened to the water. How would the teacher asses an experiment such as this?. (CCL, group,4)

Participants emphasized the necessity of making individualized ongoing assessment consistent with the conceptual change approach.

-Time

Participants perceived time as on issue, which needs to be struggled with. Following quote illustrates this struggle.

The most problematic aspect could be the amount of time that was taken for the children to realize the water evaporated. The teacher probably could have made this lesson shorter- but would the students learn as much or would have it been as meaningful to them? (CCL, group 4)

This reflection emphasizes the critical conflict teaching in a short period of time or teaching for understanding in a longer period of this that most pre-service teachers go through.

DISCUSSION

Findings of this research illustrated that pre-service teachers understanding of nature of scientific knowledge became centered on perceptions about scientific inquiry. That is, they perceived scientific inquiry as a means to add more products to existing body of scientific knowledge. Similar to what literature suggested about how in-service teachers' understanding of nature of scientific knowledge influence their classroom practice (Brickhouse, 1989, 1990; Gallagher, 1991), pre-service teachers' images of science teaching and learning are influenced by their understanding of the nature of science. In other words, pre-service teachers' perceptions about what teachers and students should be doing in a science learning environment, as explained in related assertions, are directly related to how they perceived scientific inquiry explained in other assertions. As stated in assertion 2, participants perceived that scientific inquiry connects school-science to scientists-science. Students should be using scientific inquiry in the way scientists do in order to learn scientific concepts. For meaningful learning to take place, students should be not only physically but also cognitively engaged in science activities. Scientific inquiry is a means to do that. Parallel to how students learn science, teachers should be using scientific inquiry to teaching science for understanding. Therefore, teachers' role is perceived as to facilitating science learning via scientific inquiry.

In conclusion, the prospective elementary teachers in this study perceived that both scientists and learners use scientific inquiry in the development of scientific knowledge. That is, scientists use scientific inquiry to accumulate more knowledge, whereas students use scientific inquiry to learn science for conceptual understanding. If scientific inquiry is central in scientists' and students' work, school science should reflect what scientists do scientific inquiry. Therefore, a theory that emerges from the data in this research suggests that changes in pre-service teachers' perceptions of teaching and learning science for understanding parallel changes in their perceptions of nature of scientific knowledge and scientists' work. Changes in their perceptions were increasingly characterized by scientific inquiry and, consequently, became more salient in their explanations of science and science teaching/learning. They began to place more emphasis on meaningful student learning of science by including more conceptual components versus an activity-based orientation.

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