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Relationships of Preservice Early Childhood Teachers' Cultural Values, Ethical and Cognitive Developmental Levels, and Views of Nature of Science

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Abstract

This study explored relationships between preservice early childhood teachers' views of nature of science (NOS), cognitive developmental levels, and their cultural values. Using the Views of Nature of Science Questionnaire (VNOS-B) and interviews, we assessed views of NOS. The Learning Context Questionnaire (LCQ) was used to determine the cognitive levels. Using the Schwartz Values Inventory, we determined cultural values. We analyzed the preservice teachers' views of NOS by searching for patterns in responses to the VNOS-B by Perry position on the LCQ. We used SPSS to find significant correlations between cultural values and associated subscales' cognitive levels. We found that though preservice teachers at all Perry positions held misconceptions about NOS, there were patterns of views by position; those at the position of dualism described their views in terms of one right truth, while those at the multiplicity position described their views in terms of analyzing evidence from many different interpretations.

Introduction

An understanding of the nature of science (NOS) has been determined to be an important component of scientific literacy for all (AAAS, 1993; DeBoer, 1991). Scientific literacy is a central goal for science education because it provides basic scientific understanding so citizens can satisfactorily navigate through our technological world. To be scientifically literate, it is not sufficient for students to have an understanding of only science content but also develop informed ideas for how scientists go about their work, along with the values they hold and assumptions they make while developing scientific knowledge, or NOS. Among the aspects of NOS that are deemed most accessible to K-12 students, it has been found that teachers have difficulty understanding that social and cultural contexts play a role in the development of scientific knowledge (Lederman, 1992; NSTA, 2000). One cannot teach what one does not know. We describe research into influences on teachers' understandings.

There is empirical support for success in enhancing preservice teachers' conceptions of NOS through elementary science methods courses (e.g., Barufaldi,

Bethel, & Lamb, 1977; Shapiro, 1996), particularly when using an explicit reflective approach to help teachers develop more accurate conceptions of these NOS aspects (Abd-El-Khalick & Akerson, 2004; Akerson & Abd-El-Khalick, 2003; Akerson, Abd-El-Khalick, & Lederman, 2000). Recent work indicates, however, that attainment and retention of NOS views is difficult for preservice teachers (Akerson, Morrison, & Roth McDuffie, 2006; Lederman & Lederman, 2004). Even when views of NOS are changed and improved, the views are not cohesive, and not all students are able to retain new understandings. There have been explanations advanced to determine why some preservice teachers develop more informed understandings than others, such as their orientation toward deep or surface learning and their views of the relationship between religion and science (Abd-El-Khalick & Akerson, 2004) and their cognitive developmental levels (Akerson et al., 2006). Research on learner characteristics promises to be fruitful in describing influences on attainment and retention of informed NOS views. The purpose of this study, therefore, was to explore the relationship between preservice teachers' views of NOS and their cognitive levels as defined by Perry's scheme (1999). Furthermore, we explored the relationship between preservice teachers' cultural values and their understandings of the subjective and sociocultural NOS.

Theoretical Framework

To frame our study, we drew upon the recent literature in NOS, undergraduate students' cognitive development, and cultural values. Each of these areas is reviewed below.

Nature of Science

NOS 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). In their nature of science position statement, the National Science Teachers Association (2000) recommends that science, along with its methods, explanations, and generalizations, must be the sole focus of instruction in science classes. Their position on what teachers and students should know includes the following:

- Scientific knowledge is both reliable (one can have confidence in scientific knowledge) and tentative (subject to change in light of new evidence or reconceptualization of prior evidence).
- No single scientific method exists, but there are shared characteristics of scientific approaches to science, such as scientific explanations being supported by empirical evidence, that are testable against the natural world.
- Creativity plays a role in the development of scientific knowledge.
- There is a relationship between theories and laws.
- There is a relationship between observations and inferences.
- Though science strives for objectivity, there is always an element of subjectivity in the development of scientific knowledge.
- Social and cultural contexts also play a role in the development of scientific knowledge.

These NOS elements are the focus of the present study.

Cognitive Developmental Levels

In examining research on preservice teachers' development of NOS views, we consider that, as with children's learning, attention needs to focus beyond classroom interventions and approaches to include an investigation of where preservice teachers are in their cognitive development as we explore their NOS views. One perspective that holds promise for describing cognitive levels is William G. Perry's scheme (1999). Perry's work explores adult cognitive development and relates it to ways of learning. We are using his scheme to describe our preservice teachers' cognitive developmental levels and determine whether there is a relationship to their understandings of nature of science aspects. Perry's scheme lists nine positions of cognitive development for adult learners, which we will describe below.

Perry makes no presumptions about the length of time a person may remain in a position, thus, the positions are more fluid than Piaget's developmental stages (Woolfolk, 2006). Though Perry's original scheme contains nine positions, most researchers clump them together to make them easier to understand and interpret. The most common clumping method produces four stages: (1) dualism, (2) multiplicity, (3) relativism, and (4) contextual relativism. The first three stages, dualism, multiplicity, and relativism, describe epistemological and intellectual development. The last stage, contextual relativism (which is actually Perry's positions 6 through 9), describes moral, ethical, and identity formation. We used the Learning Context Questionnaire (Kelton & Griffith, 1986), which clumps the Perry positions into the four stages just described.

Individuals at the dualism position believe that authorities possess absolute truth. People at this position hold that there is a definite right/wrong and good/bad dichotomy and that the truth is known by authorities and only needs to be learned by them. At the multiplicity position, students begin to note that the world is not as cut and dry and right/wrong as they originally thought. They recognize but oppose pluralism, complexity, interpretation, and abstractness and instead think of authorities as good and bad holders of information. Within this position, students still believe there is truth, but there is also room for uncertainty. They also believe, however, that uncertainty is only temporary until the truth is known, and if there are no right answers, there are also no wrong answers. They now seek to know what the authorities want from students and how they can "give it to them" so they can successfully pass a class or test.

In the relativism position, students adopt a way of knowing that requires a totally new understanding of all knowledge being contextual and relativistic. This position is much different from earlier ones that built upon a foundation of knowledge as dualistic. Metacognition is developed in this position. Relativistic thinking is at first conscious and then becomes a habit. Authority becomes open to debate, analysis, and evaluation. Conflicting authorities are recognized, going through the same world as students except they have more experience. Once students attain the position of relativism, they do not return to dualism because they have developed a new habit of thinking. In the commitment to the relativism position, students find relativism disorienting. Students see that developing commitments will help establish orientation. They may feel unable to make a decision, establish a commitment, or narrow the possibilities, but they feel a need to do so. We predict that preservice teachers at the dualism or multiplicity positions will have less informed views of NOS than those at later positions, as was found in previous studies (Akerson et al., 2006; Phillipson-Mower, 2005).

Cultural Values

An exploration of cultural values holds promise in further describing preservice teachers' NOS understandings. Fleer (2006) recommends that early childhood science methods instructors keep the understanding that the preservice teachers themselves are undergoing a cultural change as they consider bridging the viewpoint of themselves as early childhood instructors to that of science instructors at the forefront of their instruction. This cultural bridging could also be taking place as preservice teachers develop authority and power for instruction and management of children, as well as negotiating the differences between their own cultural backgrounds and those of their students (Buzzelli & Johnston, 2002). In a similar vein, McGinnis (2006) recommends combining cultural considerations and their impacts on teachers' professional lives. Slay (2001) noted that research in cross-cultural perspectives has not provided practical solutions to issues faced by science teachers; however, we believe that with appropriate attention to cultural values and their relationships to understandings of content, including NOS content, we can provide practical solutions to science teachers. Lemke (2001) notes that science education literature views science teaching and learning as social activities conducted within larger cultural contexts that are connected to cultural beliefs and values. Thus, our study of NOS, cognitive level, and cultural values holds promise in providing new information to the field of science education.

Schwartz (1992) postulated that cultural values could be aggregated into ten domains: (1) universalism, (2) benevolence, (3) tradition, (4) self-direction, (5) stimulation, (6) hedonism, (7) achievement, (8) power, (9) conformity, and (10) security. We used the instrument he developed and tested in 20 countries (the Schwartz Value Inventory) to measure our preservice teachers' cultural values and then related them to their NOS views and cognitive developmental levels.

Method

The Early Childhood Education Teacher Education Program is a cohort program leading to a BA degree with certification to teach in preschool and K-3 settings. As a cohort program, students move as a group through three consecutive semesters of block courses and field placements (spring semester of sophomore year and fall and spring semesters of junior year), and then have two full semesters of student teaching. Seventeen preservice teachers who were juniors participated in the study. Data from these students provided insight into relationships between preservice teachers' views of nature of science and their cultural values and cognitive levels.

Data Collection

On the first day of the semester, preservice teachers were recruited to participate in the study. All 17 agreed to participate and filled out questionnaires to measure their views of NOS, cognitive development levels, and cultural values. The researchers were not course instructors.

To measure the preservice teachers' NOS understandings, we used The Views of Nature of Science version B (VNOS-B) instrument (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) questionnaire. A subset of five students (approximately 30%) were randomly selected and interviewed to establish valid interpretation of the questionnaire responses and allow us to encourage students to elaborate on their responses.

We used the Learning Context Questionnaire (LCQ) (Kelton & Griffith, 1986) to measure the preservice teachers' ethical and cognitive developmental levels. This instrument was developed and validated for use with college students and consists of 50 items (26 of which are scored) that are marked on a six-step scale from strongly agree to strongly disagree. The questionnaire sorts the student responses into the Perry positions of dualism, multiplicity, contextual relativism, and dialectial commitment to relativism.

We used the Schwartz Values Inventory (SVI) (Schwartz, 1992) to describe participants' cultural values on the ten subscales noted previously. This quantitative Likert scale instrument has been validated and used with numerous students and teachers in at least 20 countries.

Data Analysis

Preservice teacher responses to the VNOS-B surveys and interviews were tabulated, and then views were coded independently by each researcher as either "informed" (indicating a fully developed understanding of the NOS aspect), "adequate" (indicating a developing view), or "inadequate" (indicating a misconception held by the student). The interviews allowed us to elaborate on and clarify student responses. Additionally, the interviews allowed us to validate our interpretation of the written survey responses, enabling us to ascertain whether we were interpreting the written responses accurately. The researchers' analyses were compared, and discrepancies were resolved through discussion or consensus.

The LCQ results were analyzed by assigning item scores to the appropriately positively and negatively weighted items and then obtaining the total score for each individual. The total scores enabled us to assign Perry positions to each participant.

Responses to the SVI were entered into SPSS and totaled by subscale and total score on the instrument. Correlations were run for subscales, total scores, and total LCQ responses to determine whether there were any relationships between subscales and relationships between cultural values and cognitive developmental levels.

Results

Results of the study are presented in the following subsections. We describe cognitive developmental levels, cultural values, and views of NOS by Perry position.

Cognitive Developmental Levels

The LCQ enabled us to note at which Perry position each individual preservice teacher fell and the number of students at each position. There were eight preservice teachers at the Perry position of dualism. This position indicates that these students are at the cognitive level of believing that there are right and wrong answers and that the teacher holds the knowledge that is then given to the student. There is no room in this position for opposing viewpoints or differing interpretations of ideas or evidence, possibly meaning that the participants would see science as right/wrong or completed and not subject to change, interpretation, or variance by culture.

There were seven other preservice teachers at the multiplicity position, indicating that though these participants still believe there is a right answer that we are seeking to obtain, they are also aware that there are numerous competing views and interpretations. These preservice teachers seek to know which interpretation or view is held by their instructor so they can ascribe to that view and do well in class. They may believe that scientists ascribe to various views at their own whims, not realizing that certain views and interpretations are better supported by evidence or may be interpreted differently within different cultures.

There were two preservice teachers at the relativism position. The preservice teachers at this level recognize that knowledge is contextual and relative to other knowledge and contexts. They view authorities, including teachers, as open to debate. They may believe that scientists' knowledge is also contextualized and relative, possibly in a larger sociocultural context. They may believe that scientific knowledge is open for debate by other scientists and other evidence. There were no preservice teachers found at the contextual relativism position.

Cultural Values

There was a significant correlation between tradition and conformity ($r=.655$, $p< .05$). Tradition refers to a respect for and an acceptance of the customs and ideas that are held in high regard by one's culture. Conformity includes values such as obedience and the self-discipline needed to restrain one from challenging and violating accepted norms and expectations. Conversely, neither self-direction nor stimulation correlated with tradition ($r=.24$ and .09 respectively) or with conformity ($r=.10$ and $r=-.05$ respectively). Self-direction is marked by an independence of thought and action. Stimulation includes a need for challenges, novelty, and a certain level of excitement so as to maintain one's motivation.

Views of NOS by Perry position

As has been found in earlier studies, no preservice teachers held adequate or informed views of all targeted NOS aspects; however, within the views described in the VNOS-B questionnaires and associated interviews, different patterns of responses were identified by Perry position. For instance, all students at the Perry positions of dualism and multiplicity describe their views of theory and law being that theory is an idea that will eventually progress into a law and that a law is scientific knowledge that is certain—it is proven knowledge. This view is consistent with the dualism position idea that there exists certain truth. One preservice teacher at the relativism position described theory as "one's thoughts and beliefs while law is based on concrete evidence," and the other stated, "Theories change, and laws are believed to be true, but there is possibility for both to change." Within these relativism statements, it is clear that there is no strong suggestion that laws are fact, but they are based on evidence. In the case of the second preservice teacher, both laws and theories are subject to change. The views of the relationship of theory and law are consistent with the Perry positions.

All preservice teachers except one at the dualism Perry position held inadequate views of the empirical NOS, by recognizing the need for data collection to support scientific claims. One preservice teacher at the dualism position stated that "science can be proven" illustrating her view of right vs. wrong but went on to say, "Science has evidence; evidence is the difference between scientific knowledge

and opinion." It was not possible to distinguish patterns of response among Perry position responses for this NOS aspect.

Regarding the tentative NOS, while no preservice teachers held informed views, those at the dualism position tended to respond in ways indicating they believed that scientists themselves do not change their minds (e.g., "scientists' minds don't change, but the theory can") or that theories change because new information is added. Those at the multiplicity position indicated that there are many viewpoints, such as "people and their ideas always change," "people create their own ideas," and "all people have different theories." Preservice teachers at the position of contextual relativism stated that "theory is not a sure thing, so will certainly change," and "we always learn new information," also consistent with their Perry position of contextualized knowledge.

Preservice teachers at the dualism position responded in ways that indicated their views of the sociocultural/subjective NOS were more in line with a right/wrong view of science, such as "they interpreted it differently" (but there is really a right answer), "they are looking at different information" (if they all looked at the same information, they would agree), and "they are choosing to see it they way they want to see it" (not the way it really is). At the multiplicity position, students responded in terms of "different opinions and points of view," "personal convictions," and "bias," as well as "looking at evidence differently," influencing scientists' interpretation of the data. These responses indicate their own view that everyone has different views and that all views are reasonable.

Regarding the imaginative and creative NOS, those at the position of dualism indicated that scientists needed to imagine ways to "come up with experiments" and to "make charts to collect data." One preservice teacher indicated that scientists could not use creativity or imagination "because it needed to be true, not imagined." These responses are consistent with the view that there exists an absolute truth. Those at the position of multiplicity and relativism had the more sophisticated understanding that scientists used imagination for different levels of investigation, such as "they imagine what could happen" "to figure out how to test something," "to think of ways to structure their data," and to "reason with their data to come up with conclusions." These statements are consistent with the multiplicity viewpoint that there are many ways to think about ideas and make interpretations.

Most preservice teachers at the positions of dualism and multiplicity held inadequate views of the distinction between observation and inference. Five preservice teachers (three at dualism and two at multiplicity) thought scientists could see atoms through microscopes and were thus certain of their structure. This belief is consistent with the idea that "seeing is believing" and could relate to the idea of absolute truth by viewing the evidence. Two others at the multiplicity position held more adequate views as indicated by their statements "scientists create models of atoms based on what they do," and "scientists use instruments to come up with images and ideas of the atom." These statements indicate they believe that scientists also use indirect evidence to develop scientific knowledge, and we also infer that preservice teachers at this position recognize multiple interpretations of indirect evidence. Interestingly, neither student at the position of relativism responded to this question.

Discussion

As may be predicted by Perry (1999), most of these preservice teachers (at the junior level of their college education) fall at the positions of dualism or multiplicity. We found only two preservice teachers at the relativism position. Though Perry's work began with college freshmen, he noted that it took much time progressing through college to change positions and that students could revert to earlier positions when confronted with different ideas. He did find more students at the multiplicity positions at their junior year in college, which is consistent with our findings—seven of our preservice teachers were at the multiplicity position, which is just one fewer than the eight we found at the dualism position.

It is evident from our analysis that preservice teachers at all Perry positions of cognitive development hold NOS misconceptions. This finding is not surprising given that previous studies have found that most adults, including practicing scientists, hold misconceptions about NOS (Pomeroy, 1993). Equally evident, however, is that the pattern or type of response varies by Perry position. Preservice teachers at the dualism position described and elaborated their responses to the VNOS-B questions in ways that were in line with their view of the world as filled with "truths" and "right/wrong" positions. For example, when describing their views of the tentative NOS, their responses indicated they believed that the only way scientific knowledge could change would be to add new information, bringing us closer to the truth. This belief is in contrast to those at the multiplicity position who held the view that all people hold different interpretations of data and that these interpretations could change based on people's viewpoints—consistent with their position's idea of many views of the world. This pattern of distinction in kinds of responses holds true for most of the NOS misconceptions.

Responses on the Schwartz Values Inventory present an interesting pattern of findings. The correlation between tradition and conformity presents a picture of preservice teachers who value obedience and the self-discipline needed to restrain one from challenging and violating accepted norms and expectations. These individuals are very concerned with maintaining the views, expectations, and norms that are presented to them. Rather than challenging views and ideas, the preservice teachers appear to value the self-discipline obedience necessary to uphold them. Conversely, the lack of correlation of self-direction and stimulation with either tradition or conformity provides a portrait of preservice teachers who value and willingly accept the conventional ideas and views of their culture rather than seek out novel points of view that challenge taken-for-granted ideas. Taken together, this data offers partial support for those studies reporting that preservice teachers, as a group, are less likely to challenge the traditional values and views present in many schools.

Based on the understanding that these preservice teachers hold inadequate views of NOS, it is essential that instruction be undertaken to improve their views of NOS such that they can provide appropriate instruction to their own future students. Recognizing and taking into account their cognitive levels can provide insight into appropriate NOS instruction and improve their views. For example, now that we know that many of our students have a dualistic epistemological view, we can plan instruction that can challenge that view of scientific knowledge. For example, explicit lessons about the tentative NOS couched in scientific inquiry that are then connected with a reflective discussion regarding multiple views and interpretation of the data may enable these preservice teachers at the dualism position to acknowledge the existence of multiple views. Preservice teachers could

engage in an activity that required them to build a circuit using a battery, bulb, and wire, for instance. The preservice teachers should find several different ways to solve this problem. A classroom debrief that draws the preservice teachers' attention explicitly to the multiple solutions of the problem, through which the teacher highlights the existence of multiple views, may help the preservice teachers improve their dualistic epistemological views.

In a future study, we intend to provide a semester of explicit reflective NOS instruction adapted to take into account the multiple cognitive developmental levels of our students. Additionally, we intend to emphasize the ideas of sociocultural influences on persons' (including scientists') interpretations of data and their world. We will measure any changes in views of NOS, cognitive development, and cultural values as we track our instruction, hoping to see whether we can enhance the preservice teachers' NOS views and see patterns in these enhanced views by Perry position. We will also look at any changes in cultural values and their relationships to students' views of the sociocultural NOS. To see whether these preservice teachers retain their new views or whether retention of these new views is dependent upon Perry position, we will measure their views of NOS, cultural values, and Perry position five months after the conclusion of the intervention semester.

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