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Preservice elementary teachers' conceptions of science: science, theories and evolution*

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The intent of the present study is to describe preservice elementary teachers' understanding of science and how certain contextual variables contribute to this understanding.

Eighty students in three sections of an elementary science methods course participated in the study by completing a questionnaire. Six questions dealt with knowledge of science, theories and evolution. In addition, a 21-item rating scale covering various aspects of science and science teaching was included.

The major theme arising out of the data is how beliefs affect preservice teachers' understandings of science. The anthropocentricity in the subjects' definitions and purposes of science, theories and evolution is the most explicit and pervasive of the beliefs influencing the conceptualizations of science. The often vague and misinformed definitions of theories add a further dimension of how science is perceived. When evolution is introduced, both the anthropocentric view of science and the misunderstood notion of theory come together to confound the subjects' understanding. When asked about the teaching of evolution, the subjects' confusion concerning the nature of science becomes strikingly evident.

Introduction and background

The research reported here concerns the beliefs about the knowledge of science that preservice elementary teachers hold. The intent of the present study is to describe Ontario preservice elementary teachers' understandings of science and theories and to describe some of the contextual variables that contribute to their understandings and beliefs about the nature of science. The topic of evolution is introduced in the present research as a means to uncover the subjects' beliefs about science and theories. The primary assumptions behind this move are that, because of the current controversial nature of evolution, the subjects (*a*) are compelled to grapple with their own beliefs about the nature of science, (*b*) are faced with a potential conflict between opposing and simultaneously held concepts and beliefs, and (*c*) are going to respond in ways that expose their underlying and potentially conflicting concepts and beliefs about the nature of science.

Three possibilities that could address the issue of understanding the way teachers view science include (*a*) the concepts that teachers hold about the nature of science, (*b*) the beliefs that teachers have about science, and (*c*) the teachers' beliefs that create a dissonance when compared with certain science theories and concepts. Hayward (1987) suggests that 'belief contexts' are developed throughout one's life from personal experiences and contacts with family, friends and teachers. Such belief contexts contain strongly held biases that affect an individual's perceptions of the world, as well as individual decision-making. This study demonstrates how

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preservice teachers' beliefs about science confound the conceptually consistent treatment of science topics, such as evolution. The significance of this study lies in its interactionist approach to exploring preservice teachers' beliefs about the nature of science. In addition, in looking at prospective elementary teachers, it points to the issue of how teachers can affect the development and construction of a foundation of scientific knowledge among young children.

Although numerous studies have addressed teachers' concepts and beliefs about science, none has focused on the conflicts and interrelationships between beliefs about creationism, evolution, scientific theories and science itself. For example, Duschl (1983) looked at teachers' beliefs about the nature of science and how such beliefs affected the selection, implementation and development of instructional tasks. Lederman (1986) found that secondary science teachers had an adequate conception of the nature of science based on results of the 'Nature of Scientific Knowledge Scale' (Rubba 1976). Lederman's results contradicted earlier results from other researchers (Behnke 1961, Miller 1963, Schmidt 1967, Carey and Stauss 1968, 1970). Similarly, H. O. Anderson *et al.* (1986) found that preservice secondary science teachers in 1984 showed a significantly greater understanding of the nature of science (based on the results of Kimball's (1967) 'Nature of Science Scale') than their counterparts in 1969. However, most of the previous research has focused on the scientific literacy of pre- and inservice secondary science teachers and secondary students. The assessment instruments used to measure science literacy focused on 6 characteristics of scientific knowledge in the case of Lederman and on 29 characteristics in the case of Anderson and others. Basically, the research to date has taken a rather static look at teachers' knowledge of the nature of science.

Other papers have addressed the creationism–evolution issue in terms of science curriculum, focusing on (*a*) the treatment of evolution in textbooks (Skoog 1984, Rosenthal 1985, Beard 1986), (*b*) content issues (Kenkel 1985) and (*c*) the epistemological or philosophical analysis of creationism and evolution (T. Anderson and Kilbourn 1983, Gatzke 1985, Gardner 1984). None of these articles, however, looked at the dynamics of the interrelationships between beliefs in creationism, concepts of science and scientific theories, and teacher decisions about how to teach evolution.

The significance of this study, therefore, lies in its interactionist approach to exploring preservice teachers' beliefs about the nature of science. In looking at prospective elementary teachers, the present research takes on the added dimension of pointing to the issue of how teachers can affect the development and construction of a foundation of scientific knowledge among young children. In addition, the need for further research is suggested in a discussion of how such interaction among beliefs has the potential for affecting the way science is presented in the elementary classroom.

Method

During the first class of the term and prior to any discussion of the course, students in three sections of an elementary science methods course were asked to participate in the study by completing a questionnaire. Of the 106 students enrolled, 80 students completed the task. All of the students held a BA degree and had returned to university for a bachelors of education degree and teacher certification.

The questionnaire contained several items on personal and academic background, including, age, sex, size of home town, BA major, science courses taken in high school and university, and other involvement with science-related activities. In all, 21 questions were asked about science and science teaching; these required short answers and the completion of a concomitant rating scale on one's confidence in each answer. However, for the purposes of the present paper, only six questions are considered in detail:

1. How would you define science?
2. What is the purpose of science?
3. What is a theory?
4. How are theories used in science?
5. What is evolution?
6. Should evolution be presented in the classroom? If so, how should it be presented? If not, what aspects of science should be presented?

In addition, a 21-item rating scale on a variety of statements about previous experiences with science, the nature of science, science teaching, evolution, and creationism, was included at the end of the questionnaire.

Results

The results are presented beginning with an overview of the background of the subjects and then proceeding with a discussion of the subjects' experiences in science courses. The next section deals with the subjects' views on various aspects of science, followed by sections on the purposes of science, conceptions of theories, and, finally, conceptions of evolution and creationism.

The subjects in the present study ranged in age from 22 to 47 years, with over 76% between the ages of 22 and 27. Over 86% of the subjects were women. Approximately 70% of the subjects grew up in medium to large metropolitan areas. The most striking of the background statistics involved the number of natural science courses taken at university level. The number of courses ranged from 0 to 13, with over 47% of the subjects having no science courses and over 28% having 1 or 2 courses. Most subjects indicated that they enjoyed watching science and nature programmes on television and reading science and nature magazines, but fewer subjects enjoyed reading books on science. Biology and earth science were the more popular science courses taken in both high school and university. In general, the subjects rated science laboratory activities higher than lectures, although the ratings of the lectures were distributed nearly along a normal curve.

In the descriptive questions about how science was taught in high school and what the subjects liked or disliked about science, four views were most common:

1. those who disliked science or some aspect of it found the extensive lecturing to be boring and difficult to follow;
2. those who disliked science found the subject to be over their heads and geared towards men or the 'extremely intelligent';
3. those who liked science enjoyed the hands-on laboratory experiments; and
4. those who liked science enjoyed the feeling of excitement involved in making new discoveries and finding out how things work.

Most of the subjects felt frustrated by their experiences in science courses, even though they may have enjoyed science informally by the time of the survey. For example, one student commented that science 'is interesting. [It is] fascinating to become aware of the world around us. [However] prescribed experiments are not fun because they require prescribed results (which I rarely achieved)'. Much of the frustration encountered with science appears to result from the abstractness of the material (especially in chemistry and physics), which invariably involved the extensive use of mathematics. On the other hand, many subjects liked the concrete aspects. Representative of a large number of the respondents was the statement: 'I like science because the answers are applicable to life. There is a feeling of "real" discovery'. Other subjects indicated that they had developed an affinity for science after graduating from university. School science seemed to develop negative feelings, yet their interest in nature led them to explore science topics on their own.

Although a few subjects had totally good experiences with science in high school, many had mixed or negative feelings about science. Of particular interest was how the subjects felt about whether their preparation in science equipped them to design science activities for classroom teaching. Asked how they felt about teaching science, almost all of the subjects felt at least reasonably confident. Did the subjects feel that they had learned how to identify problems and design experiments in the previous science courses? Most of the subjects felt they had some training in how to identify problems, whereas the subjects were more evenly distributed in their perceptions of their training in designing experiments. However, when asked to rate their feelings toward designing science activities and helping students to design experiments, the ratings tended to show a more positive outlook. Whether or not such a positive view of teaching science is substantive, the subjects had tried to lay aside some of the negative feelings towards their experiences in science courses and had developed a more optimistic view of teaching science in the future.

Aspects of science

When asked to rate how important it was for students to understand various aspects of science, a large majority of the subjects agreed that it was important for students to understand (*a*) science methods, (*b*) science concepts and (*c*) science theories (see figure 1). However, in order to understand these ratings, it is important to look at what the preservice teachers understand about the nature of science and scientific theories.

In response to the question 'How would you define science?' most of the subjects referred to science as a 'study of the world' (see figure 2). In this definition, a number of terms during data analysis were included as synonyms for 'world', such as (*a*) universe, (*b*) nature, (*c*) phenomena (observable and natural), (*d*) environment (physical, natural and man-made) and (*e*) living organisms. Within the basic category of a 'study of the world', the subjects' answers tended to elaborate on specific aspects of what they considered a part of science. A few examples of such aspects were (*a*) laws governing the environment, (*b*) man's relationship and interaction with the environment, (*c*) searching for explanations, (*d*) explaining causes, (*e*) predicting, (*f*) understanding why and how, and (*g*) everything we do. The sophistication of the responses varied considerably. For instance, one subject (S29) replied with 'the study of nature and matter'. However, another subject (S40)

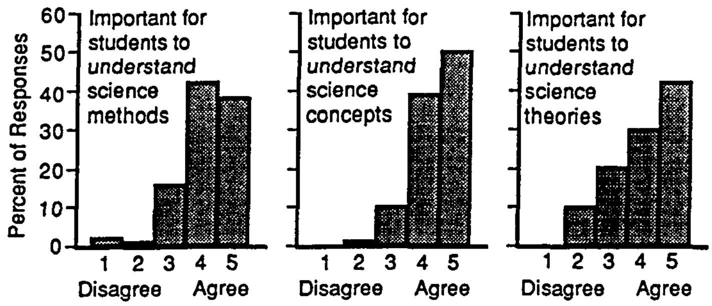

Figure 1. Frequency distributions of subjects' views on the importance of science methods, concepts and theories in teaching science.

explained that 'Science is the study of the world around us, both living and non-living. A study of the environment and the way animals and plants interact. The development of the natural world is discussed. An attempt to explain the world using scientific methods'. Definitions provided by some subjects tended to lean towards one particular scientific discipline, for example physics or biology. As in the definition provided by subject 40, above, many subjects focused on the environment and environmental issues, which frequently included references to 'Man'.

The second category of definitions of science focused on 'process' or the methods of science. Again, the complexity of responses varied. Included in this category were (*a*) the act of investigating, (*b*) exploration, (*c*) employment of the scientific method, (*d*) problem solving, (*e*) observation, (*f*) experimentation, (*g*) empirical research, (*h*) systematic testing of hypotheses, (*i*) quantification, (*j*) generalizing, (*k*) deductive reasoning, (*l*) testing and (*m*) application of derived knowledge. In contrast to the previous category (study of the world), most of the answers falling into the 'process' category were in combination with another category, most typically the 'study of the world'.

Within the 'body of knowledge' category, the subjects' responses included (*a*) body of thought, (*b*) system of knowledge, (*c*) set of facts, (*d*) a discipline, (*e*) pursuit of knowledge and (*f*) gaining or learning new knowledge. The complexity of these answers varied and were usually combined with another definition category. One unique definition was put forth by subject 56:

> Science is a body of thought and field of study, the chief definitive factor of which is the use of the 'scientific method' as the method of gathering data/observation and 'testing' theories. I could also define science as the religion of our time in terms of the common view of it and its claims to pure objectivity and omnipotence...

This definition incorporated several categories, including an aspect (i.e. science as religion) that appears in the 'other' category in figure 2. Interestingly, subject 56 had taken no science courses at university level.

The last category, 'search for new developments', contained two basic references: (*a*) medicine and (*b*) new technology. In this case, science was seen as a service to man, a response which was more commonly found as an answer to the question 'What is the purpose of science?' (see discussion below).

Throughout the subjects' definitions of science the notion of each individual's beliefs about the nature of science becomes apparent. One of the more common beliefs that can be inferred from the data is that science is centred on people, a belief

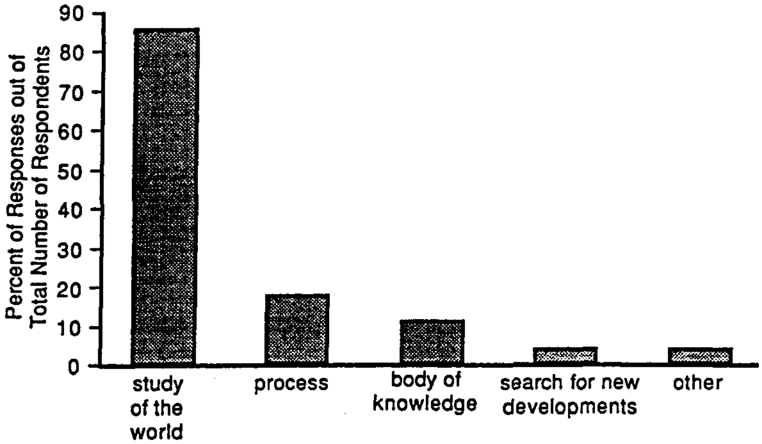

Figure 2. Frequency distribution showing the major categories of the subjects' definitions of science.

that is evident in at least 44% of the subjects' definitions (based on the occurrence of the words: man, us, we, people and our). Specifically, 14% of the subjects made references to (*a*) 'our world', (*b*) 'our environment', (*c*) 'our physical surroundings', (*d*) 'our lives', (*e*) 'our universe' or (*f*) 'elements of our existence'.

Purposes of science

The beliefs about the nature of science become more apparent when the subjects' answers to the question 'What is the purpose of science?' are analysed. All of the six basic categories relating to purpose (see figure 3) point to the centrality of human beings in science. The extreme notion of science as a way of manipulating the world in order to benefit humans is expressed in two categories, those concerned with (*a*) improving the quality of life and (*b*) establishing a human identify, which between them accounted for 31% of the subjects. Some examples of these two categories are as follows:

1. Science is necessary for the advancement of mankind...
2. ...to find cures for illness, to develop new and better ways of living.
3. ...to improve the quality of living for man... to allow man to exploit the earth to improve his quality of life.
4. So that discoveries can be made to advance the way of life in the world–to make things better and in some cases easier.
5. ...to contribute to a holistic view of who we are.
6. To discover components of the universe and their purpose in relation to man...
7. To enable humans to identify themselves in the universe.
8. ...inventions to aid us in future survival.

Many of these statements about the purpose of science were made in conjunction with other categories, particularly that of understanding the world. Basically, the logic followed the pattern of: 'to understand our world so that...'. The common theme throughout all of the categories was a concern to make sense out of our world,

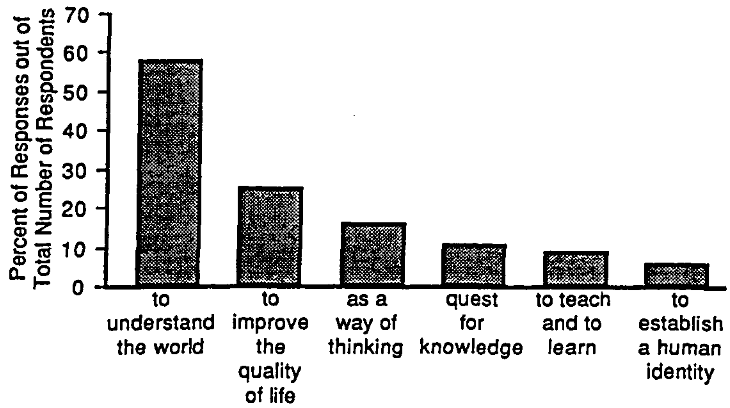

Figure 3. Frequency distribution showing the major categories of the subjects' beliefs about the purpose of science.

such as answering relevant questions, satisfying curiosity, solving environmental problems and developing ways of thinking that will help us survive.

As a whole the subjects' views about the nature of science up to this point, although quite variable in substance, are reasonable, especially in view of the fact that most of the subjects have little or no background in science. However, as we delve more deeply into the subjects' portrayals of the nature of science by examining the subjects' definitions of theories and their purposes, a different picture of the preservice teachers' understanding of science begins to emerge.

Conceptions of theory

The definitions of theory that emerged (see figure 4) exhibit a more disjointed variety of beliefs about the nature of theories. At one extreme, the definitional categories of (*a*) belief, (*b*) assumption, (*c*) opinion and (*d*) guess account for 30% of the subjects' definitions. As in the responses to the previously discussed questions, the definitions of theory frequently spanned two or more categories. However, in the case of theories, such combinations point to the subjects' confusion about both terms and

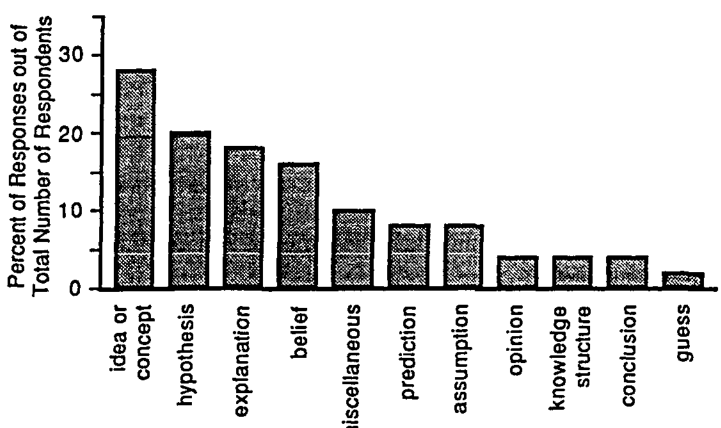

Figure 4. Frequency distribution of subjects' definitions of theory.

the theories themselves. For instance, the following subjects' responses demonstrate some of the linkages:

S18: A *belief* or *hypothesis* that has been tested numerous times and usually developed by one individual or a group who share the same findings.
S29: A *hypothesis* or *assumption* about why something happens.
S81: A *belief*... or *explanation* as to why something happens or exists, etc. [emphasis added].

Such confusion and vagueness is further demonstrated in the definitions that fall into a number of these categories:

S17: A theory is a group of sentences that are formulated to answer the why in why something occurs...
S22: An explanation that explains a known fact.
S23: ... an educated guess about something...
S26: A theory is an idea about something...
S27: An idea/a way of explaining some phenomena. A theory is not a fact.
S33: ... an idea... about a particular subject.
S36: A statement of cause without factual evidence...
S43: At best a good guess.
S53: An opinion as to what a person believes to be true.

In general, most of the definitions provided by the subjects were characterized by an ambiguity of meaning. The term 'idea' itself is unclear; and when this term is seen in context, it becomes even more obscure. For example, a common vague usage of 'idea' is represented in subject 33's statement that a theory is 'an idea... about' something.

Only 4% of the subjects approached the notion of a theory as a knowledge structure, vaguely alluded to in the responses that suggested theories are explanations. Subject 57, for example, stated that 'A theory is a hypothesis. A theory is a perspective which effectively orders the chaos... so that it becomes comprehensible, hence it explains reality to us be it various facets of reality [or] how they relate to each other. E.g., there are theories about nuclear fission... a molecular theory... theory of evolution'. Even though she has put together a more complex definition than any of the other subjects, her first statement that a theory is a hypothesis does not quite fit with the rest of the explanation.

To add to the complexity of preservice teachers' understanding of theories, the views expressed about how theories are used seemingly become more accurate (see figure 5). In particular, the notions that theories are (*a*) starting points or bases for further research, (*b*) used to explain phenomena, (*c*) guides or structures for organizing information or further research and (*d*) used to formulate hypotheses, represent 76% of the subjects' responses. However, many of the responses put forth by the preservice teachers are in combination with more vague statements. For instance, subject 29 suggested that 'theories are used as a guide or to show direction. They are the first act before conducting the research'. Here the notion of theory is one of conjecture. On the other hand, subject 40 stated that theories 'are used as a basis for further scientific exploration. They are the beginning point in many ways and they provide a framework in which one can investigate phenomena'. Although the notion of conjecture may still exist, this subject's statement about 'framework' adds a more robust quality. However, in general, most of the subjects' responses were characterized by a lack of robustness similar to subject 29's statement.

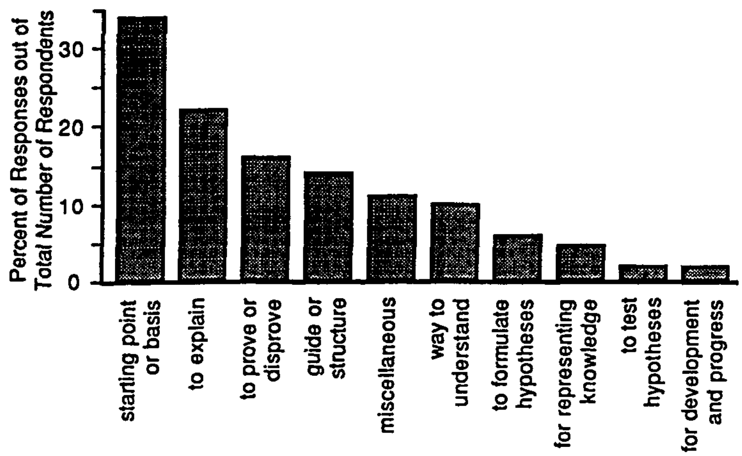

Figure 5. Frequency distribution of subjects' response to the question of how theories are used.

Conceptions of evolution and creationism

In an attempt to look at the preservice teachers' concepts and beliefs about the nature of a specific theoretical framework, the subjects were asked to respond to several items on the rating scale and to answer two short questions about evolution. The subjects were asked to rate their agreement with three statements about creationism and evolution. Approximately 39% of the subjects rated that they believed in creationism and only 27% rated they did not (16% did not respond); 23% of the subjects believed that creationism has a scientific basis. However, when asked to rate the statement 'evolution has no factual basis', only 6% agreed and 63% disagreed. An allegiance to a belief in creationism does not seem to be related to the subjects' assertions that evolution has a factual basis.

When asked to respond to the question 'What is evolution?' the preservice teachers' responses varied considerably in substance. However, a strong emphasis on humans as the focus of evolution was evident (see figure 6). Of their responses 45% contained references to the evolution of man or humans as the primary focus. The following are a few examples of such a view:

S20: A theory about the creation of man.
S26: Evolution is a theory about how man evolved–only the fittest organism survives and changes as a result of changes in the environment.
S27: A theory of how man came to exist. Man evolved from another species.
S29: The process of change which occurred to produce the product of man. The fact that man evolved from the sea.
S66: *The progression of man from (a) apes (b) God.*
S70: Evolution is the theory that man evolved from animals.

Almost all of the subjects who referenced 'man' had similar statements to the ones above. The anthropocentric bias of the subjects' beliefs about evolution is extensive. Not surprisingly, the frequency distribution of such a focus closely matches the frequency of a human reference in the subjects' definitions of science.

As can be seen in figure 6, many of the words appearing in the definition of evolution are what one might expect, for example, (*a*) change, (*b*) theory, (*c*)

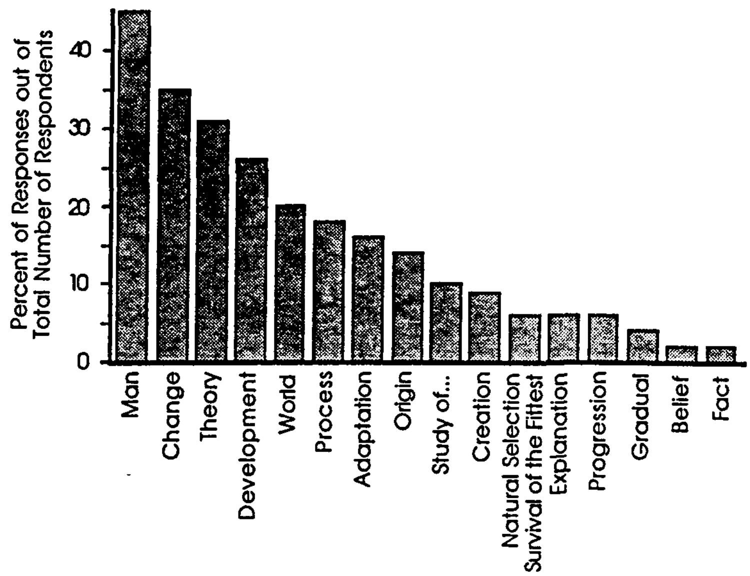

Figure 6. Frequency distribution of terms used in the subjects definition of evolution.

development, (*d*) process, (*e*) adaptation, (*f*) origin and (*g*) natural selection and survival of the fittest. Some of the responses, however, implied other beliefs or biases about evolution. According to Gould (1984), the four biases typically associated with evolution are (*a*) progress, (*b*) determinism, (*c*) gradualism and (*d*) adaptationism. Progress, or the notion that evolutionary change is directed at developing better and more refined organisms (in particular, the ladder of evolution with man at the top), is the most common and obvious of all the biases in the subjects' responses. As we have already seen in the discussion of 'man' as the focus, the idea expressed is that the development of human beings is the goal of evolution. Other examples of the 'progress' bias include:

S73: How things evolve from one form to another higher life form.
S100: The theory which explains that we have arrived to this point by a process of mutations from a 'lower' form that increased in physical/mental (intellectual) capacity.
S25: Evolution is the advancement of something over time. It is a theory that says that over thousands of years things evolved... modify themselves from a need.

Determinism, or the notion that evolutionary change is purposeful and systematic, is implied in a number of the subjects' definitions:

S61: A species keeps the best of its traits while developing new ones and getting rid of old ones.
S92: The gradual development [gradualism] of a species... through systematic changes brought about by adaptation to environment.

Gradualism, or the notion that change occurs in a series of slow steps, is apparent in a few of the subjects' responses. The term gradual occurred in 4% of the responses (see the example of subject 92, above). Adaptationism, or the notion that every organism has evolved to fit together perfectly and exists for a purpose, is not as apparent in the subjects' responses. Essentially, all of the biases are concerned with the intrinsic or extrinsic belief that humankind is the central figure of the world. The biases support such a notion by supplying a somewhat logical rationale for evolution as the process or force that places humankind at the top, above all other organisms.

Discussion

The major theme arising out of the data is the notion of how beliefs affect preservice teachers' understandings of science. The anthropocentricity in the subjects' definitions and purposes of science, theories and evolution is the most explicit and pervasive of the beliefs permeating and influencing the conceptualizations of science. The often vague and misinformed definitions of theories add a further dimension to how science is perceived. When evolution is introduced, both the anthropocentric view of science and the misunderstood notion of theory come together to confound the subjects' understanding.

The first point that needs to be addressed is the notion of theory and its importance in understanding science. As a simple, yet accurate, definition of theory, Lerner and Bennetta (1988, p. 37) state that 'a theory is a structure of ideas, confirmed by preponderant evidence, that explains a body of observations and so explains some aspect of nature'. A detailed discussion of the ongoing arguments over the structure of scientific theories is not particularly appropriate in this paper. However, some elaboration on the above definition is necessary. The 'structure of ideas' can be thought of as a theoretical framework which is absolutely necessary for science to take place. According to Schwab (1964), both stable and fluid inquiry are based on the existence of a *theoretical framework*. Scientists that observe a discrepancy in their data are able to acknowledge the discrepancy because of the theoretical framework; the observed does not fit into the theory. Other scientists may formulate a problem based on a gap or a missing or weak relation in a theory. Fundamentally, all of science and every part of science has its foundation in theory. As Hayward (1984, pp. 76–77) points out:

1. Observation is theory laden... what one observes depends on one's theories and expectations.
2. Meanings are theory dependent. The meanings of descriptive terms (e.g., electron, wave) used in a theory change as the theories change...
3. Facts are theory laden. What counts as a fact depends on the belief system associated with a theory...

In other words, all of our scientific understandings are grounded in theory. Theories provide the framework for developing a coherency of meaning, however tentative and changing it might be.

High school textbooks add to the confusion surrounding the notion of theory. Lerner and Bennetta (1988) found that most high school science textbooks provide conflicting views of theories. In various parts of one textbook theory is equated with (*a*) a belief, (*b*) a myth, (*c*) a legend, (*d*) an idea, (*e*) a hypothesis, (*f*) a guess and (*g*) an opinion. Of this list of synonyms for theory, (*a*) and (*d*) through (*g*) were all used by the subjects in the present study. Lerner and Bennetta's analysis demonstrates how many textbooks rarely mention 'theory' prior to the chapter on evolution. Then, the term 'evolution' never appears without being attached to 'theory of'. The confusion that arises in the treatment of theory as belief or opinion can lead to treating evolution in ways that suggest the phrases 'opinion of evolution', 'belief of evolution', and so forth.

In Hayward's (1984) treatment, the notion of theories as part of a belief system is a significant point in the attempt to analyse the potential for confusion. In a sophisticated sense, theories are beliefs. Theories are incorporated as building blocks in the construction of belief systems. However, the way in which theories are 'beliefs' is quite different from the way the subjects in the present study viewed theories as beliefs. Epistemologically, theories as beliefs are empirically based. Theories are grounded in beliefs of our observations and observations are grounded in our theoretical beliefs (Martin 1972). The way in which the subjects referred to theories as beliefs appears to involve the notion that theories are about believing in one's own thoughts apart from empirical observations. If such a notion of theories is an accurate depiction of the subjects' concepts of theory, then personal, religious and scientific ideas or 'theories' stand on the same logical ground.

However, there is a basic problem in the comparison of different logical types (Bateson 1979). Personal and religious beliefs are at a different level of abstraction from scientific beliefs. Some of the subjects in this study assert that evolution should be presented along with creationism, so that students can decide for themselves which to believe. Such a comparison does a great disservice to the students by producing, as Bateson would have said, a muddle. The theories (contributing to the belief system) involved in the concept of evolution are based on considerable empirical evidence, while the beliefs involved in creationism are based on religious doctrine and faith intertwined with a great deal of emotional attachment. The fundamental problem in attempting to compare creationism and evolution so that a choice of allegiance can be made is that there is no foundation for choice. Such a demand is like asking a child to choose between pretending to be the frog prince and observing and investigating frogs. These two activities are of two different classes of ideas or information. A choice could be made, but the basis for selecting one over the other would be emotional.

If we expect to portray an accurate picture of science in our classrooms, it is necessary to discriminate between the beliefs (theories) held by scientists and other types of belief. Attempts to compare information from different types of belief systems without taking into account logical and epistemological conflicts will only create much unnecessary confusion.

What does this mean to the classroom teacher? In dealing with the topic of evolution, teachers should have a clear understanding of the difference in logical typing of the theories of evolution and the beliefs involved in creationism. However, presenting the notion of logical typing to young children is probably too abstract. So, when presenting information related to evolution, especially with younger children, teachers should avoid comparisons with biblical accounts of creationism. Such a comparison would only add to the confusion that results from the mixing of logical types.

The anthropocentric view of science evident in varying degrees throughout the subjects' treatment of science, theories and evolution brings up a number of concerns regarding teachers' beliefs about science. As we have already seen, theories are beliefs in the sense that they are based on the subjective perceptions of scientists. To add further subjectivity, in terms of an anthropocentric view, only serves to further confound the problems involved in the interpretation of perceptions and in the communication of the nature of scientific observation and of the scientific endeavour, in general.

The subjects' assertions that science is geared towards the development of technology and the improvement of the quality of life lead to a belief that separates humankind from the rest of the natural world. Even the statements put forth by the subjects, such as 'the purpose of science is to understand *our* world' (emphasis added), promote a division between people and the world they live in. Such separation fosters a lopsided approach to making decisions about environmental and technological issues.

Anthropocentrism also interferes with the development of an accurate and sophisticated understanding of evolution. The entire thrust of Gould's (1984) four biases towards evolution is centred around the notion of anthropocentrism. Such a biased understanding places evolution on ground more compatible with religious beliefs, by incorporating a different logical typing of belief into the concept of evolution. In other words, the empirically based conception is modified to incorporate a view of evolution that places humankind at the pinnacle and that creates a predestined and consistent perspective on the natural world. Such a view conforms with personal beliefs that offer some security in feeling distinctive, as well as with religious ideals of a neatly designed world with humankind as the ultimate physical being. Anthropocentric beliefs when incorporated into understandings of evolution not only misrepresent evolutionary theories, but confound the understanding of science.

Teachers whose task it is to teach science in the elementary school are faced with a challenging task if they seek to offer an accurate picture of science and scientific theories. How do teachers present evolution and the idea of theory? One of the subjects in the present study stated that her science teacher would talk about Darwinian evolution interspersed with readings of verses from the Bible on the creation of man. That particular student advocated the teaching of evolution not as a 'theory' or alongside creationism, but as a straightforward unit on the topic. But what happens to other students exposed to the same teaching? What beliefs do those students develop who are exposed to teachers who use the previously discussed synonyms for theory and phrases like 'just a theory'?

Throughout the sequence of the results, as they have been presented in this paper, the reasonable quality of the subjects' discussions of science, theory and evolution decreased. It is not unreasonable that the views held by the subjects (who were training to be elementary school teachers) are likely to influence their approach to the teaching of evolution. Such teaching is bound to be affected by the subjects' personal beliefs about religion, science, theories, evolution, creationism, the world and themselves.

Obviously, much more research is needed in the area of inservice and preservice teachers' beliefs in the nature of science, the nature of the world, themselves as an identity, and so forth. How do such beliefs affect the way understandings of science are constructed? How do such beliefs manifest themselves in the classroom? How do they affect students' beliefs and learning? What meaningful approaches can be taken during the training of teachers to help clarify the nature of science?

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References

Anderson, H. O., Harty, H. and Samuel, K. V. 1986, Nature of science, 1969 and 1984: perspectives of preservice secondary science teachers. *School Science and Mathematics*, Vol. 86, pp. 43–50.

Anderson, T. and Kilbourn, B. 1983, Creation, evolution and curriculum. *Science Education*, Vol. 67, pp. 45–55.

Bateson, G. 1979, *Mind and Nature: A Necessary Unity* (Bantam Books, New York).

Beard, J. 1986, Comment on 'Evolution in high school biology textbooks: 1963–1983' by Dorothy B. Rosenthal, *Science Education*, 69 (5): 637–648, 1985, *Science Education*, Vol. 70, pp. 501–502.

Behnke, F. L. 1961, Reactions of scientists and science teachers to statements bearing on certain aspects of science and science teaching. *School Science and Mathematics*, Vol. 61, pp. 193–207.

Carey, R. L. and Stauss, N. G. 1968, An analysis of the understanding of the nature of science by prospective secondary science teachers. *Science Education*, Vol. 52, pp. 358–363.

Carey, R. L. and Stauss, N. G. 1970, An analysis of experienced science teachers' understanding of the nature of science. *School Science and Mathematics*, Vol. 70, pp. 366–376.

Duschl, R. A. 1983, Science teachers' beliefs about the nature of science and the selection, implementation, and development of instructional tasks: a case study. Doctoral dissertation, University of Maryland, 1983. *Dissertation Abstracts International*, 4502A.

Gardner, K. L. 1984, The evolution controversy in the educational literature from 1900–1981 discussed in terms of Kuhn's 'Structure of Scientific Revolutions'. Doctoral dissertation, Northern Illinois University, 1984. *Dissertation Abstracts International*, 4504A.

Gatzke, K. W. 1985, Creationism as science: What every teacher-scientist should know. *Science Education*, Vol. 69, pp. 549–555.

Gould, S. J. 1984, In Nova (WGBH and BBC-TV, producers), *Stephen Jay Gould: This View of Life* (WGBH Educational Foundation, New York).

Hayward, J. W. 1984, *Perceiving Ordinary Magic* (Shambhala Publications, Boston).

Hayward, J. W. 1987, *Shifting Worlds, Changing Minds* (Shambhala Publications, Boston).

Kenkel, F. L. A. 1985, A case against scientific creationism: a look at content issues. *Science Education*, Vol. 69, pp. 59–68.

Kimball, M. E. 1967, Understanding the nature of science: a comparison of scientists and science teachers. *Journal of Research in Science Teaching*, Vol. 5, pp. 110–120.

Lederman, N. G. 1986, Students' and teachers' understanding of the nature of science: a reassessment. *School Science and Mathematics*, Vol. 86, pp. 91–99.

Lerner, L. S. and Bennetta, W. J. 1988, The treatment of theory in textbooks. *Science Teacher*, Vol. 55, pp. 37–41.

Martin, M. 1972, *Concepts of Science Education: A Philosophical Analysis* (Scott, Foresman and Company, Glenview, IL).

Miller, P. E. 1963, A comparison of the abilities of secondary teachers and students of biology to understand science. *Iowa Academy of Science*, Vol. 70, pp. 510–513.

Rosenthal, D. B. 1985, Evolution in high school biology textbooks: 1963–1983. *Science Education*, Vol. 69, pp. 637–648.

Rubba, P. A. 1976, *Nature of Scientific Knowledge Scale* (School of Education, Indiana University, Bloomington, IN).

SCHMIDT, D. J. 1967, Test on understanding science: a comparison among school groups. *Journal of Research in Science Teaching*, Vol. 4, pp. 365–366.

SCHWAB, J. J. 1964, The structure of the natural sciences. In G. W. Ford and L. Pugno (eds.), *The Structure of Knowledge and the Curriculum* (Rand McNally, Chicago), pp. 31–49.

SKOOG, G. 1984, The coverage of evolution in high school biology textbooks published in the 1980's. *Science Education*, Vol. 68, pp. 117–128.