An Investigation of Preservice Elementary Teachers' Thinking *About* Science

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Abstract

It is not common to find media reports on the failures of science education; nor uncommon to hear prestigious scientists publicly lament the rise of anti-science attitudes. Given the position elementary teachers have in influencing children, anti-science sentiment amongst them would be a significant concern. Hence, this article reports an investigation where preservice elementary teachers responded to the *Thinking about Science* survey instrument. This newly developed instrument addresses the broad relationship of science to nine important areas of society and culture and is intended to reveal the extent of views being consistent with or disagreeing with a commonly held worldview of science portrayed in the media and in popular science and science education literature. Results indicate that elementary teachers discriminate with respect to different aspects of culture and science but they are not anti-science.

Introduction

There appear to be many prominent scientists vexed by the extent of anti-science attitudes in the public (Bishop, 1995; Dyson, 1993; Greenwood, 1996; Holton, 1993; USN&WR, 1991). They join a long tradition of the intelligentsia complaining about the low estate of public literacy in one domain or another. Historical precedence is neither validation nor invalidation for the present concerns these scientists have about anti-science attitudes. While they may have a point, reasons of these attitudes must be sought. Our particular concerns are with elementary teachers. Elementary teachers are not known to be "science types." With regard to science knowledge and attitudes about science, they are more like the lay public in general than they are like secondary science teachers and others with science degrees. Given their position as teachers of children, anti-science sentiment amongst elementary teachers would be a significant concern. Our report is about the development of the "Thinking about Science" survey instrument, designed both for pedagogical purposes with preservice elementary teachers and for research to elucidate anti-science sentiment within this group.

THEORETICAL BACKGROUND

Many scientists and science educators are concerned about the public's ambiguous relationship with science and general level of alienation with science (see e.g., Dworkin, 2001; Holton, 1994; Kurtz, 1994; Nemecek & Yam, 1997; Park, 2000). This public includes elementary teachers and indeed the elementary grades have been cited as a weak point in science education (Gardner & Cochran, 1993). Like many citizens, it may also be that many elementary teachers find science disconnected from everyday life and thinking. Is science merely a "school" subject, unimportant in everyday life? Does science conflict with important personal beliefs related to cultural knowledge, religion or art? Elementary teachers who feel this disconnection with science would at best approach science teaching as something one does if school authorities demand it.

Though there are no studies that specifically address the question of anti-science attitudes amongst elementary teachers, there are suggestions in the research literature that such negative attitudes exist (Gustafson & Rowell, 1995; McDuffle, 2001; Parker & Spink, 1997; Palmer, 2001; Skamp & Muehler, 2001; Stephans & McCormack, 1985; Talsma, 1996; Tosun, 2000; Yates & Chandler, 2001).

It is critical to keep in mind what is expected of elementary teachers as teachers of science. If that expectation is limited to simply involving students in science activities, such as growing and observing plants or rolling carts down inclined planes, then the teacher's engagement with science is minimal. Perhaps elementary science teaching requires only what Wallace & Louden (1992: 508) characterize as "getting the 'formula' right, trying harder, doing it better, spending more money." Wallace & Louden (1992, p. 508), however, go on to say that,

> There is an alternative view which questions why, after more than three decades on the reform agenda, elementary science teaching continues to disappoint. Is it because we haven't found the right 'formula' or could it be that we have an imperfect understanding of the problem and unrealistic expectations for the solution?

We concur with Wallace & Louden's doubts. Moreover, given the promotion of constructivist approaches to science teaching among teachers who frequently face the challenges of multiculturalism, standardized testing and the rising challenges of science itself, society's demands on elementary teachers today are all the greater. These demands increasingly require of teachers an engagement with science at a significant level of depth and sophistication – a critical engagement with science.

For some, a critical engagement with science simply means studying more science. Their perspective is that science is itself unproblematic. Science is, in other words, a self-evident good. We as a research team are science enthusiasts, but our reading of the history, philosophy and sociology of science suggests it is not unproblematic. Because science ultimately, like anything else, has to be communicated within the public square; and, a communication is always an interpretation of what is meaningful and valuable to the communicator, the accuracy of the science content notwithstanding. We suggest that in this sense of being problematic, some aspects of science are likely to be a source of friction, concern, and alienation for some people, including elementary teachers.

The problematic nature of how science is to be communicated and with what values is at the heart of C. P. Snow's "Two Cultures" metaphor (Snow, 1963). C. P. Snow's 1959 Rede Lecture, "The Two Cultures and the Scientific Revolution," captured attention for a debate that began in the 19th century between T. H. Huxley (1881/1963) and Matthew Arnold (1882/1963). "Shall science be the guiding principle for social development? Or are there values that science cannot deal with, some higher values?" (Hultberg, 1997, p. 2). Huxley (1881/1962, p. 45) argued the affirmative noting that, "Not only is our daily life shaped by it, not only does the prosperity of millions of men depend upon it, but our whole theory of life has long been influenced, consciously or unconsciously, by the general conceptions of the universe, which have been forced upon us by physical science." Though Arnold appreciated the value of scientific knowledge, he considered that knowledge to be coldly rational, disintegrated, lacking any aesthetic dimension, and utterly incapable of enlightening what it means to be human or humane. Scientists and humanists, as Snow would later say, dwell in different cultural worlds. A sense of that difference is captured in the contrast between the following two passages from Walt Whitman (1959) and Charles Darwin (1888):

Whitman	**Darwin**
When I heard the learn'd astronomer, When the proofs, the figures, were ranged in columns before me, When I was shown the charts and diagrams, to add, divide, and measure them, When I sitting heard the astronomer Where he lectured with much applause in the lecture room, How soon unaccountable I became tired and sick, Till rising and gliding out I wandered off by myself, In the mystical moist night-air, and from time to time, Look'd up in perfect silence at the stars.	I have said that in one respect my mind has changed during the last twenty or thirty years. Up to the age of thirty, or beyond it, poetry of many kinds... gave me great pleasure, and even as a schoolboy I took intense delight in Shakespeare... I have also said that formerly pictures gave me considerable, and music very great, delight. But now for many years I cannot endure to read a line of poetry: I have tried to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music... I retain some taste for fine scenery, but it does not cause me the exquisite delight which it formerly did... My mind seems to have become a kind of machine for grinding general laws out of large collections of facts ...

Unlike Huxley, C. P. Snow was actually quite sympathetic to the humanities (he was himself an author of novels) and very supportive of placing science within the liberal arts – Sheila Tobias (1994) is certainly correct to use Snow's arguments in her plea for liberal education that integrates the natural sciences. Snow was concerned that the dispassionately objective knowledge of science be counterbalanced by knowledge that reflected humanity and values. Snow's arguments, however, were more motivated by an outmoded British scientific/industrial system in contrast to Soviet accomplishments exemplified by Sputnik. He wanted the public to understand that science had transformed the modern world including society, and that 19th century values were obsolete. He unabashedly called the humanists who demurred, "modern Luddites." And just as Huxley was challenged by Matthew Arnold, Snow was challenged by F. R. Leavis who charged that Snow was simply echoing the ideology of scientists at the expense of the humanities and of human dignity (Leavis & Yudkin, 1962). Nonetheless, the impact of Snow's lecture is such that it has been axiomatic since the lecture's publication for anyone discussing the issues of science vis-à-vis culture, the humanities, or liberal education to invoke the "Two Cultures" metaphor. There is the sense that Snow recognized the existence of a critical gap between natural scientists and others of a more humanist bent, and that he profoundly addressed what needed to be done about it within the context of a liberal education. If that is so, one has to wonder what F. R. Leavis was so upset about?

To the contrary, what is lost in these discussions is that Leavis had a legitimate criticism of Snow's perspective: Snow *overestimated* scientific power and epistemological privilege. As if to emphasize this overestimation, twenty years later the eminent neurophysiologist John Eccles wrote that,

> There has been a regrettable tendency of many scientists to claim that science is so powerful and all-persuasive that in the not-too-distant future it will provide an explanation in principle for all phenomena in the world of nature, including man, even of human consciousness in all its manifestations…. Popper has labeled this claim as *promissory materialism*, which is extravagant and unfulfillable. Yet on account of the high regard for science, it has great persuasive power with the intelligent laity because it is advocated unthinkingly by the great mass of scientists who have not critically evaluated the dangers of this claim false and arrogant claim. (Eccles, 1979, p. i)

Of course, not all scientists make the claim of *promissory materialism* but some very well known scientists certainly have. Francis Crick offers his Astonishing Hypotheses that, "'You,' your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules" (1994, p. 3). Eccles presciently cautioned in 1979 that the danger risked by indulging in such extravagant claims for science is the precipitation of anti-science sentiment. Thus, Eccles would not be surprised by Sheila Tobias (1994), noting the rise of anti-science sentiments, telling us that the gap between the "Two Cultures" is greater today than it was when Snow gave his seminal lecture over 30 years ago. As if in planned emphasis of Tobias' observation, the "Science Wars" between scientists and postmodernists broke out in 1997 (see *Nature*, 1997). What one should learn from the arguments between Huxley and Arnold, Snow and Leavis, and to a lessor extent the recent clash between some very vocal scientists and equally vocal postmodernists, is that resistance to science cannot be reduced to the simplicity of "science versus anti science." There are competing worldviews across which communication remains difficult. Thus, even though most lay citizens grant power and significance to science, in the public square science remains problematic for many people.

Although we agree that it is better for teachers to take more science courses than less, there are other ways for students to have a critical engagement with science. We work from a cultural/constructivist perspective that values learning by way of discourse over a wide range of ideas that students have about science, society and culture. It is important that science not be taught from an "internalist" perspective. This is a perspective that does not recognize the relevance students can find between ideas that are personally important, on the one hand, and school science on the other (Cobern, 2000). Developing connections with prior knowledge – especially with knowledge traditionally thought of as external to science – is important if students are to have a critical engagement with science. In several previous articles, we have provided discussion about science with respect to a broad range of philosophical, sociological and cultural ideas (Cobern, 1995; Cobern, Gibson & Underwood, 1995; Cobern & Loving, 1998; Loving, 1991&1998; and Loving & Foster, 2000). We are extending our current work to include a new survey that probes thought on "public image" – that is, the image of science often presented in the public square.

We are talking about attitudes but not attitudes toward science as usually understood in the science education community (Koballa, 1992). Nor do we have in mind nature of science (NOS) issues, which tend to involve a more internalist perspective on science (Lederman, 1992). There are many existing instruments in both of these areas, but these instruments do not address the public place of science with respect to society and culture. Closer to our interests is the VOSTS instrument (Ryan & Aikenhead, 1992; Aikenhead & Otsuji, 2000), which provides insight on student views related to science and society for specific STS issues. What we have done differently is to draw upon the widely read work of high profile scientists, science popularizers, science educators and cultural and political commentators. These are important people because it is their views that create much of the public image of science. We drew themes from these sources for an instrument that addresses the broad relationship of science to important areas of society and culture. Our work serves both a pedagogical purpose and a research purpose. The survey discussed below is used with students in an elementary science methods course as way to stimulate and provoke discussion on the importance of science and why our society should want science to have a vital place in the elementary school curriculum. The research purpose is to investigate the presence of anti-science attitudes amongst preservice elementary teachers and illuminate their valuations of science vis-à-vis the "Public Image" of science.

INSTRUMENT DEVELOPMENT

Specifically, the *Thinking about Science* instrument is composed of 35 items developed on the basis of objections to science (as discussed in the previous section) and defenses for science. the authors wrote the items based on themes taken from the literature. Some of the items were adapted from items that Cobern and Loving (1998) used in a previously published study. the items are grouped by nine categories described below. These categories are *not* intended to represent an *authoritative* scientific worldview, but a scientific worldview *version* commonly found in both the popular media and the popular literatures of science and science education. In the balance of this article, the categories below describing a public image of science will be referred to as the *Model*. Example citations are provided for each category with one exception. "Science, Race and Gender" is actually more of a goal for how things ought to be, but are not yet. Rosser (1995, p. 4) has argued that, "many scientists would suggest that science is 'manless' as well as 'womenless'" (also see Bianchini, Whitney, Breton & Hilton-Brown, 2001).

Epistemology
Science is a superior, exemplary form of knowledge that produces highly reliable and objective knowledge about the real world. (Elby & Hanner, 2001; Feynman, 1995; Gross & Levitt, 1993; Leone, 1987; Monod, 1971; Singer, 2000; Wilson, 1998).

Science & the Economy
Modern industrial, commercial, and information-based economies depend on scientific developments for increasing production, wealth and general public welfare. (Alperts, 2000; Glenn, 2000; Hurd, 1989; Lawler, 2000; Leone, 1987)

Science & the Environment
Science is necessary for the discovery, development, conservation *and* protection of natural resources and the environment in general. (AAAS, 1990; Bond, 1999; Knopman, 1997; Polkinghorne, 1996; Raven, 2002)

Public Policy & Science
Science acts in the public interest. Science should thus be supported by public funds, however, the science community is more than capable of policing scientific activity. (Alperts, 2000; Gross & Levitt, 1993)

Science & Public Health
The conquering of disease and physical affliction and the great advances in public health are made possible by science and will not continue without science. (Clark, 1989;

NIH, 2001; Sampson, 1966)

Science, Religion & Morality
People make moral choices about the use of scientific findings but science itself is morally neutral. Science is also neutral with regard to religion. The importance of science, however, is such that science must be protected from the intrusive activities of some religions. (Brush, 2000; Gould, 1987 & 1997; Larson & Witham, 1998; Maddox, 1994; NAS, 1998; Weinberg, 1999)

Science, Emotions & Aesthetics
Scientists are often passionate about their work but the work of science best proceeds on the basis of objective reason and empiricism. There is a beauty to science. Indeed, "elegance" is often required of scientific ideas. (Dawkins, 2000; Polkinghorne, 1996; Shlain, 1991)

Science, Race & Gender
Science is an "equal opportunity employer." Race, gender and other personal factors are irrelevant in science. This is the ubiquitous claim of the science community.

Science for All
The importance of science is such that it should be taught at all levels of schooling. Every citizen should have attained at least a minimal level of science literacy. (AAAS, 1990; NRC, 1996)

The original list of potential item statements was sent to 40 scientists and science educators for comment and then the items were accordingly revised. Teams of three to six preservice elementary teachers were then asked to interpret in writing the meaning of each revised item. The students were randomly assigned to review a random sample of items. This was done to further insure that students would generally interpret the items as intended. Many students found this to be an awkward task and tended to respond to items rather than simply interpret what the items were saying. Nevertheless, even such responses gave a good indication of how the students interpreted each item. Based on the students' written comments, the researchers judged that most readers of the survey items would interpret each item closely to the intended meaning (the actual data is available for review, see Cobern, 2001).

Subsequently, a survey was composed of 60 items calling for responses in the form of a 1-5 scale. The "1" was labeled "strongly disagree." The "3" was labeled "uncertain," and the "5" labeled "strongly agree." One of the authors used the survey for instructional purposes with students in an elementary science methods course between 1997 and 2001. Almost 700 students participated. All of these preservice elementary teachers were either seniors or second semester juniors in a degree program that includes the elementary science methods course as a part of a 21-hour, mathematics/science minor at a large midwestern university. At the time of the survey, the students had each taken three courses in science and two in mathematics. On the first day of the methods course the students were told that a survey was to be given and that the survey results would be used during a class discussion later in the semester. The students were also told, however, that participation was voluntary and anonymous. Virtually all students participated. The student population was typical for an elementary teacher certification program. The vast majority were between the ages of 20 and 35. A few were non-traditional older students. Less than 10% of the students were persons of color. Most of the students were women. With regard to ACT scores and grades in general education, university required courses, the students compared very well with the rest of the university. The data for this period is reported in Cobern (2001).

The theoretical framework reported above justified the original set of 60 items with construct validation by experts and commonsense understanding of the wording by students. However, for the purpose of the current research, and to provide the most efficient instrument for future instructional use, the survey was further pared to a set of 35 items (see Tables 1a&b). Using the data from all the preservice teachers who had taken the survey as part of their elementary science methods course, the original 60 items were subjected to an inter-item correlation analysis as grouped by categories. Within categories, positive inter-item correlations and similar items means were used as the criteria for retaining items. This process eliminated 26 items as being redundant. The Alpha reliability coefficient for the finalized instrument of 35 items was calculated at 0.8188. The individual category coefficients are given in Table 1, which lists the items by category.

Table 1a. Items Grouped by Categories followed by Response Frequencies (%)

	SDA*	DA	?	A	SA
Category 1: Epistemology (EPIST)					
Scientific knowledge is the most objective form of knowledge.	4	14	50	27	5
We can be certain that scientific knowledge is reliable.	8	37	31	21	2
The methods of science are the most reliable source of true, factual knowledge.	4	25	38	29	4
Science is the best source of reliable knowledge.	6	29	39	24	2
Scientific knowledge is the truest form of knowledge.	9	28	48	13	2
Alpha = 0.7475					
Category 2: Scientific & the Economy (ECON)					
Science helps develop our natural resources such as coal, gas, oil, and solar energy.	4	6	11	45	33
Scientific knowledge is useful in keeping our national economy competitive in today's world.	3	4	19	53	22
There are many good things we can do today because of scientific knowledge.	2	1	1	39	57
The development of our natural resources, such as coal, gas, oil, solar energy, is dependent upon having adequate scientific knowledge.	2	7	21	55	15
Scientific knowledge is useful for only a few people. (Scored in reverse)	1	4	6	57	32
Developing new scientific knowledge is very important for keeping our country economically competitive in today's world.	1	3	12	57	26
Scientific knowledge is useful.	1	1	2	42	53
Alpha = 0.7528					
Category 3: Science & the Environment (ENVIR)					
Our natural environment would actually be helped by the absence of scientific knowledge. (Scored in reverse)	3	8	23	46	21
Science can help us preserve our natural environment and natural resources.	1	5	9	65	20
Without science we will not be able to preserve our natural environment and natural resources.	2	14	27	45	12
Alpha = 0.4772					
Category 4: Public Regulation of Science (POLY)					
There is little need for the legal regulation of scientific research.	35	42	19	3	2
Scientists should not be allowed to research anything they wish. (Scored in reverse)	12	22	27	29	10
Scientific research should be carefully regulated by law. (Scored in reverse)	16	46	28	9	1
Alpha = 0.7757					

* SDA= strongly disagree; DA= disagree; "?"= not sure; A= agree; SA= strongly agree

Table 1b. Items Grouped by Categories followed by Response Frequencies (%)

Category 5: Science & Public Health (HEAL)	**SDA***	**DA**	**?**	**A**	**SA**
Scientific research makes important contributions to medicine and the improvement of public health.	1	2	3	50	44
Scientific knowledge contributes little to good health. (Scored in reverse)	2	5	7	54	32
Alpha = 0.5652					
Category 6: Science & Religion (RELIG)					
Science is a more important source of knowledge than religion.	28	28	25	13	5
Religious knowledge contributes more to the well being of a person's life than does science. (Scored in reverse)	11	21	37	23	7
Alpha = 0.5463					
Category 7: Science & Aesthetics (BEAUT)					
Scientific explanations tend to spoil the beauty of nature. (Scored in reverse)	2	13	22	47	15
Science can contribute to our appreciation and experience of beauty.	1	7	16	59	17
Alpha = 0.4129					
Category 8: Science, Race & Gender (RACE)					
Women are welcome in science just as much as men are.	6	26	15	22	30
The scientific community is mostly dominated by white men and is often unfriendly to minority people. (Scored in reverse)	8	36	33	19	4
African Americans and other minority people are just as welcome in the scientific community as are white people.	7	21	29	21	21
The scientific community is mostly dominated by men and is often unfriendly to women. (Scored in reverse)	10	27	40	16	6
Alpha = 0.7686					
Category 9: Science for All (For_All)					
Students should not be forced to take science courses at the university. (Scored in reverse)	4	12	13	40	30
Science should not be made an important subject for the elementary school grades. (Scored in reverse)	4	3	2	24	66
Understanding science is a good thing for everyone.	2	2	5	43	48
All students should study science during the secondary school grade levels.	2	2	3	39	53
Most people really do not need to know very much science. (Scored in reverse)	2	2	3	39	53
Even at the university level all students should study at least some science.	2	6	7	47	37
Science should be taught at all school grade levels.	2	4	6	41	47
Alpha = 0.8031					

* SDA= strongly disagree; DA= disagree; "?"= not sure; A= agree; SA= strongly agree

The natures of three original categories were somewhat changed by the reduction of the number of items. These categories became more narrowly focused. The items retained under Category 4 are specifically about the regulation of science. The items retained under Category 6 are specifically about religion and science; and the items retained under Category 7 are specifically about aesthetics and science (see Table 2). The effect is that the survey does not address science and public policy (beyond the regulation of science), nor does it address issues of morality and emotions with respect to science. However, since it was never claimed that the original survey was exhaustive, these new exclusions are not considered serious for the purposes of the research, though they do suggest areas for future research

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Table 2. Comparison of Models

Original Model	Revised Model
Epistemology	Epistemology
Science & the Economy	Science & the Economy
Science & the Environment	Science & the Environment
Public Policy & Science	Public Regulation of Science
Science & Public Health	Science & Public Health
Science, Religion & Morality	Science & Religion
Science, Emotions & Aesthetics	Science & Aesthetics
Science, Race & Gender	Science, Race & Gender
Science for All	Science for All

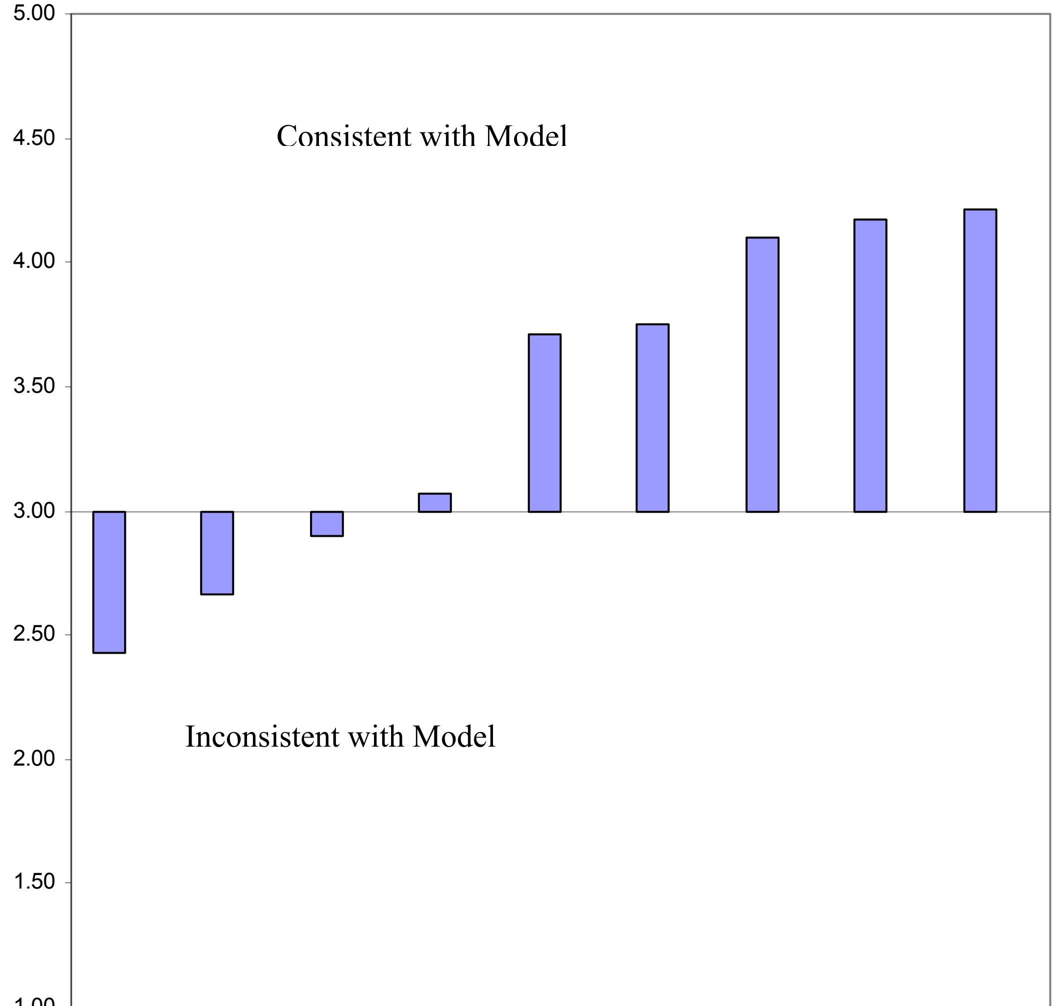
FINDINGS OF THE STUDY

The method of analysis was to develop a profile with respect to the categories of the (revised) *Model*. The items comprise the categories; hence category means based on the composite of category items were calculated to form the profiles. For instructional purposes, each student receives his or her individual profile. For the purpose of our research, a composite profile was constructed for all participants based on category means (see Figure 1). Scores of “4” and “5” for the categories indicate agreement with the *Model*. Moreover, a category mean of “5” for all nine categories would be indicative of scientistic thinking.

On the other hand, scores of “2” and “1” for the categories indicate disagreement with the *Model*; and a category mean of “1” for all nine categories would be indicative of anti-science thinking.

Five of the nine categories had means over 3.5, which can be taken as the range showing agreement with the *Model*. With a mean of 4.22, the highest-ranking category was **Science & Public Health**. With a category mean of 4.17, **Science for All** was a close second. **Science & the Economy** followed at the third rank with a category mean of 4.10. The results indicate that the preservice teachers affirm the relationship of science to good health – the conquering of disease and physical affliction and the great advances in public health are made possible by science and will not continue without science They believe that science should be taught at all levels of schooling and that every citizen should attain at least a minimal level of science literacy. They strongly affirm the importance of science in school. And, they also believe that modern economies depend on scientific developments..

Figure 1. Ranked Category Means



	POLY	RELIG	EPIST	R & G	BEAUT	ENVIR	ECON	For_All	HEAL
Means	2.43	2.66	2.90	3.07	3.71	3.75	4.10	4.17	4.22
SD	0.696	0.942	0.638	0.878	0.718	0.628	0.529	0.640	0.662

POLY	Category 4: Public Policy & Science
RELIG	Category 6: Science & Religion
EPIST	Category 1: Epistemology
R & G	Category 8: Science, Race & Gender
BEAUT	Category 7: Science & Aesthetics
ENVIR	Category 3: Science & the Environment
ECON	Category 2: Science & the Economy
HEAL	Category 5: Science & Public Health
For-All	Category 9: Science for All

The means for the next two categories exceed 3.5, and thus also indicate agreement with the *Model*, but the agreement is less strong. The fourth and fifth ranked categories are virtually tied with means of 3.75 and 3.71 for **Science & the Environment** and **Science & Aesthetics**, respectively. The preservice teachers affirm that science has a positive relationship with the development, conservation, and protection of natural resources and the environment. They do not necessarily consider science to be a threat to their aesthetic sensibilities. However, their support for science with respect to these two categories does not match their support for the top three ranked categories.

The next two categories, **Science, Race & Gender** and **Epistemology**, fall in a zone of uncertainty with means of 3.07 and 2.90, respectively. The preservice teachers appear to be uncertain over both the openness of science to women and minorities, and the claims of science to epistemological privilege. They do not necessarily reject the *Model*, but neither do they show much support.

Two of the nine categories means were close to or less than 2.5, which can be taken as the range showing disagreement with the *Model*. With a category mean of only 2.66, the preservice teachers appear disinclined to accept the *Model* with regard to **Science & Religion**: that science should be considered more important than religion. The lowest ranked category, **Public Regulation of Science**, with a mean of only 2.43, appears to be rejected. In contrast to the *Model*, the preservice teachers appear to affirm the need for public regulation of science

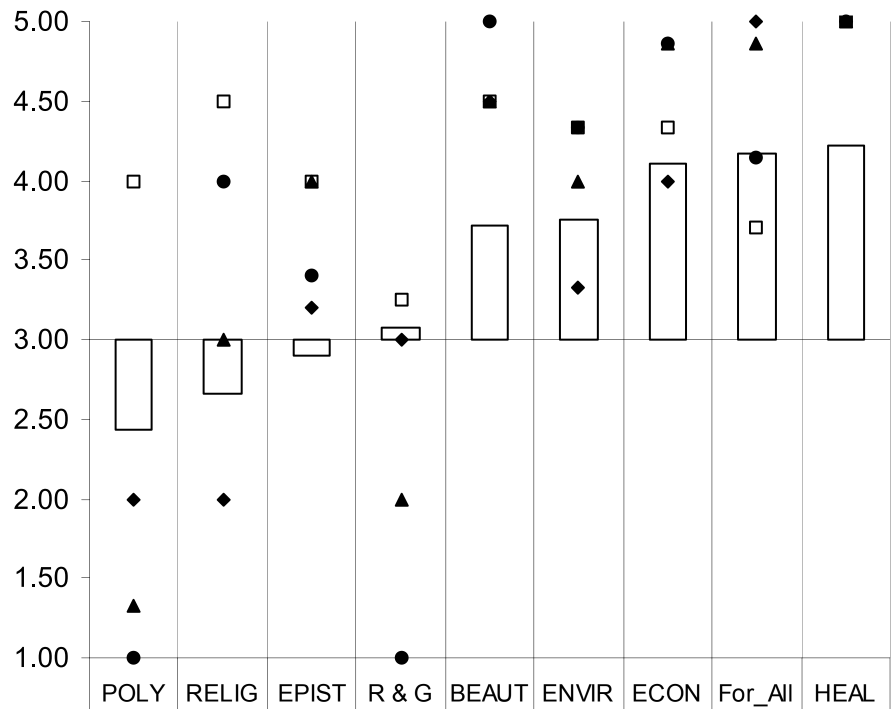
DISCUSSION

We note earlier that the *Model* is not to be taken as an *authoritative* scientific worldview but a commonly presented image of science in the public square. Hence, interpretation of results should be about the ranks, magnitudes and balance within profiles and the comparison of such amongst profiles for different groups and against the *common image* model. As one examines Figure 1, the first thing that strikes one is that the preservice elementary teachers who participated in this study are not anti-science though they have reservations about some features of the *Model*. The profiles show that the preservice elementary teachers discriminated with respect to different aspects of culture and science. They believe that science is a positive force for public health and in the economy. They support the education theme of "Science for All." They are a little more uncertain about the role science plays with respect to the environment and resource development, and also about the relationship between science and aesthetic issues. But by no means are they negative about science with regard to these categories.

The preservice elementary teachers value science, but it is clear that they do not place science at the top of some epistemological pyramid nor do they consider science more important than religion. They are also somewhat skeptical about the openness of the science community to women and minorities. On the whole, we would say that their views are about right; bearing in mind that the *Model* is not is necessarily the correct view of science. Indeed, their views are not unlike the views of some scientists – though not the ones who are typically quoted in the media. For example, we asked four scientists at a major research laboratory to complete the survey. Figure 2 shows their individual results plotted along with the category means for the preservice elementary teachers. The preservice elementary teachers are high on the same categories that the scientists are consistently high on: Science & Public Health, Science for All, Science & the Economy, Science & the Environment, and Science & Aesthetics. The scientists and preservice elementary teachers are not uniform in their support for these categories, but the differences cannot be simply laid to the fact that one group is composed of scientists. For example, the scientists all recorded fives for Science & Public Health. Given that all four scientists are bio-medical researchers one wonders if a group of non-medical related scientists would on this category return results more similar to the preservice elementary teachers than to these four bio-medical researchers? There are many sources of difference.

In contrast to these five categories, there are two other categories on which the scientists are considerably more negative than are the preservice elementary teachers. Three of the four scientists emphatically reject the *Model* position on the public regulation of science. Two for four scientists emphatically reject the *Model* position on race and gender. The other two scientists show the same uncertainty, as do the preservice elementary teachers. On religion and science the scientists are rather split. Only on the epistemology category are the scientists

Figure 2. Category Means for Four Scientists and the Preservice Teachers



	POLY	RELIG	EPIST	R & G	BEAUT	ENVIR	ECON	For_All	HEAL
□ Student Means	2.43	2.66	2.90	3.07	3.71	3.75	4.10	4.17	4.22
● Scientist 1	1.00	4.00	3.40	1.00	5.00	4.33	4.86	4.14	5.00
▲ Scientist 2	1.33	3.00	4.00	2.00	4.50	4.00	4.86	4.86	5.00
◆ Scientist 3	2.00	2.00	3.20	3.00	4.50	3.33	4.00	5.00	5.00
□ Scientist 4	4.00	4.50	4.00	3.25	4.50	4.33	4.33	3.71	5.00

more consistently positive with respect to the *Model* than are the preservice elementary teachers. Even here, however, two of the four scientists are in the zone of uncertainty. The data from the scientists thus indicates that one should not be surprised that lay people such as our preservice elementary teachers have a varied response to science with respect to important aspects of culture and society.

CONCLUSION

Does science literacy in the public need to be improved? Of course. Does this include elementary teachers? Probably so. Should we share Holton's (1994) concerns about anti-science sentiment in a lay public that includes elementary teachers? Not with respect to the preservice elementary teachers in this study. There is no hint that they are in any way opposed to science. We know that preservice teachers come to their profession with many of their own ideas about science and that these are "retained as a core philosophy" (Gustafson & Rowell, 1995, p. 600) that can aid or hinder further cognitive and affective development with respect to science. We cannot be displeased with the profiles found for our preservice elementary teachers, however; profiles that are indicative of the core philosophies the preservice elementary teachers bring to class. They simply have a judicious view of science that is an appropriate foundation for their further development as teachers of science. Thus we would concur with Levitt's finding that: "teachers are moving in a direction consistent with science education reform" (Levitt, 2001, p. 22). With respect to the differences vis-à-vis the *Model*, these suggest a need to better understand how preservice elementary teachers – and the public in general – interpret science, to better understand their interaction with a common image of science, and to better understand why some high-profile members of the science community tend to present science as they do regardless of differences even amongst scientists. Above all, we should not think someone is anti-science just because he or she does not think about science exactly as we do.

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