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A 20-Year Study of Undergraduate Astronomy Students' Beliefs and Knowledge in Science and Technology

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Abstract. This poster presents data from a 20-year study into the science literacy of undergraduates enrolled in introductory astronomy courses. Responses from almost 10,000 undergraduate students from 1989 to 2009 have been analyzed. We present students' responses to both science literacy and belief questions by year and demographic variables, as well as trends in open-ended responses. Analysis revealed that demographic variables accounted for only 7% of the variance in students' science literacy scores. The strongest predictor of a student's overall science literacy score was how many science courses they had completed, yet this only accounted for 4% of the variance, as did students' beliefs regarding science and technology issues.

1. Introduction

Although there is no consensus on the definition of science literacy, it is generally agreed that it is important for citizens to be scientifically literate in order to make informed decisions in everyday life. Miller (1993, 1998, 2004) has argued that to be scientifically literate, one must have both a basic vocabulary of scientific terms and constructs and a general understanding of scientific inquiry. In 1978, the National Science Foundation (NSF) commissioned Jon Miller and Kenneth Prewitt to lead an effort to measure the "public understanding of, and attitudes toward, science and technology" (Miller 2004). This project has resulted in reports as part of the *Science and Engineering Indicators* series that is published by the National Science Board every two years, the latest of which was published in 2010.

The best way to measure scientific literacy is also contentious, yet ongoing national surveys continue to use questions developed by Miller and Prewitt for the National Science Board project. A recent example is a report released by the Pew Research Center for People and the Press (2009), in which several of the same science literacy questions from the NSF were used. For the sake of comparison our study drew on the items used by the NSF in order to study a particular population: undergraduate students in introductory astronomy courses at a single university. Studying this population allowed us to take a closer look at the influence of college science courses on science literacy, as well as the influence of other student demographics.

2. Data Collection

A voluntary, in-class survey targeting undergraduate students' understandings of and beliefs about science and technology issues was collected from nearly 10,000 students enrolled in introductory astronomy courses at a Research I university over the course of 20 years, from 1989 to 2009. Surveys were anonymous but asked participants to report the number of college science courses they had completed, their year in school, gender, major, and GPA. The surveys were administered by participating instructors in their own classrooms at the beginning of nearly every semester during the 20 year time span. The two-page survey instrument included a set of forced-choice and open-ended items derived from the National Science Foundation (NSF) Science and Engineering Indicators (1989) and work by Miller (1987) assessing science literacy, as well as a series of Likert-scale items assessing students' attitudes about science and technology issues.

3. Results and Findings: Science Literacy

The analysis revealed that only 2.7% of students in our sample (n = 9590) answered 15 out of 15 questions correctly across all 20 years of the study (mean = 11.2, SD = 2.3). Additionally, the average number of questions correct out of 15, with the exception of two years (1989 and 1991, in which the overall average was higher) was fairly stable over the 20-year period at around 11 questions (73%) correct. The sample in 1989 had a very high proportion of science majors (62%) and the sample in 1991 was also high (14%) relative to every other year (whose peak was 4%). The high proportion of science majors may be the source for the anomalous results in these years.

Below is a table of how students performed on the science literacy survey based on their reported majors. Self-reported science majors had the best average performance while self-reported education majors had the worst average performance. This difference is, on average, two out of the 15 questions on the survey—a statistically significant, though arguably not very large, difference in overall performance.

Table 1. Results of average number of questions answered correctly out of 15, by student major, across all 1989–2009 surveys.

Major	n	Mean	Standard Deviation
Education	605	10.6	2.3
Undeclared	96	10.8	2.5
Medicine, Nursing, Pharmacy	479	10.8	2.4
Architecture and Business	408	11.1	2.3
Social and Behavioral Sciences	184	11.2	2.3
Fine Arts and Humanities	357	11.6	2.2
Engineering and Agriculture	420	11.7	2.2
Science	1758	12.6	1.8

A hierarchical multiple-regression model was used to determine if any of the self-reported demographic information contributed to, or helped to explain, students' overall science literacy scores. The multiple regression analysis revealed that taken together, the demographic variables accounted for only 7% of the variance in students' scores ($F(6,\ 8082) = 102.8$, $p < 0.05$, $R^2 = 0.07$). The strongest predictor of a student's overall score on the science literacy questions was how many science courses they had completed, which is not surprising, but only accounted for 4% of the variance explained.

4. Results and Findings: Open-Ended Question about Science Inquiry

Among the students who answered the question, "What does it mean to study something scientifically?" (n = 7490), many recognized that science is a way of building knowledge about the world (n = 1802). They were more familiar with the empirical nature of science (n=2657) than virtually any other characteristic, and they focused more on analyzing activities (e.g., Analyzing, n = 886; Breaking things down, n = 340) than synthesizing activities (e.g., Developing theory, n = 156; Explaining, n = 189; Seeking relationships, n = 305). The most popularly referenced terms were those associated with "school" science, i.e., the ones typically covered in textbooks when addressing the scientific method (n = 1057): observe/experiment (n = 2657), hypothesis (n = 1182), and theory (n = 1855). Concepts associated with more sophisticated understandings of science were more rare (e.g., questioning, n = 179). Though the notion of science "proving" ideas was prevalent (n = 383), so too were using evidence (n = 196), building support for and validating ideas (n = 527), disproving ideas (n = 180), and scientific ideas as tentative (n = 425). It was rare for students to make any reference to science as a human endeavor (n = 40).

5. Results and Findings: Attitudes Toward Science and Technology

Combining information from both theoretically-determined categories and an exploratory factory analysis, we created a model of five main categories for the 24 Likert–scale questions: belief in life on other planets, faith-based beliefs, belief in unscientific phenomena, general attitude toward science and technology, and ethical considerations. Regression analysis revealed that students' responses to attitude and belief questions had very little explanatory power with regard to performance on the science literacy questions. With a total explained variance of less than 4% ($R^2 = 0.036$), attitudes were even less predictive than demographical variables.

6. Conclusions

This study presents a preliminary look at 20 years of data collected from a similar population at a university, which is useful for examining trends in science literacy in a relatively stable population of students. These results support Miller's recent conclusion that college science courses have a significant effect on increasing scores on this science literacy measure (2007). However, it is clear that there are other intervening factors that have a much larger effect than number of science courses completed. This is interesting in light of Miller's conclusion, because this sample represents the group who are involved in taking general science courses, the greatest predictor in increasing science literary in his studies of the general population. This group of college students outperforms the general NSF population, but it is unclear what predicts their science literacy, as measured by this survey. Our findings also call into question the claim that students' beliefs are predictive of their overall scientific literacy, and have implications for instruction specifically designed to address different categories of beliefs, such as beliefs in astrology and pseudoscience. We hope that this work will contribute to conversations both within our institution and across other institutions involved in educating citizens about science.

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