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Improving the Teaching of Science for Our Future Elementary School Teachers

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Science has not always been an esteemed subject of the elementary school curriculum. Historically, it was the last of the major academic disciplines to be included in the American K-8 curriculum. In international comparisons with students from other countries, U.S. students generally rank low in science achievement. Yet, children generally love science and are naturally curious about almost everything. They are natural problem identifiers and solvers. However, oftentimes elementary school teachers spend very little time teaching this essential subject for a number of reasons. Moreover, even the State of Florida's well-publicized and contentious Florida Comprehensive Assessment Test (FCAT), has now added a science section this past school year. We, as teacher educators, must insure that we provide our pre-service elementary school teachers, who are generalists who teach most if not all the school subjects, a contemporary source of appropriate and relevant pedagogy, subject matter content, learning activities, and resources to teach science to all children of grades K-6 if we are ever to turn this cycle around.

Results of our surveys indicate that our students, upon graduation from our elementary education program, often feel inadequately prepared to teach science. However, surveys of our working graduates suggest greater confidence in the classroom. Interviews with faculty and administrators at primary and post-secondary institutions indicate that they share similar concerns about science content and pedagogy in teacher education programs. Significantly, although many institutions have increased the science requirements for pre-service teachers, they have not taken steps to coordinate institutional goals and outcomes in the Natural Sciences.

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Consequences of our failure to properly introduce natural science include lack of preparation and subsequent inability of our pre-service teachers to transmit knowledge in the classroom. As a result of our concerns, we applied for and received a grant from our

home institution, Union Institute & University (UI&U), to review the science curriculum at our university and to make recommendations to address deficiencies. UI&U is a private, nontraditional, regionally-accredited postsecondary educational institution with its main campus in Cincinnati, Ohio. Beginning the project, we were particularly concerned with the preparation of our elementary education students. Lack of preparation affects these students directly, and then ripples out to South Florida classrooms. Recently, state-approved teacher education programs in Florida have attempted to improve teacher preparation in the sciences by increasing science requirements for pre-service teachers. However, we are concerned that our private university and the state public universities may share similar problems: education students are leaving our respective programs without adequate knowledge of science or the scientific method.

One goal of this project is to investigate teacher preparation in the sciences, primarily the elementary school teachers, at our institution. At the outset of this study, we anticipated that our learners are not comfortable with basic scientific concepts including basic content knowledge and scientific method. As a result, these pre-service teachers would leave our institution not feeling adequately prepared to introduce science topics at the elementary school level. Secondly, we predicted that we would find institutional and programmatic problems within local public schools that create barriers to achieving national and local goals set for science education. We felt at the outset, based on anecdotal evidence as well as news articles, that the Florida Comprehensive Assessment Test (FCAT) would exacerbate many institutional problems with science education. Finally, we anticipated that faculty and administrators in tertiary institutions,

as well as public elementary and secondary institutions, would share similar concerns about teacher preparation in spite of changes made to improve science content education in state-approved teaching programs.

Background

Long before January 2002 when current President George W. Bush signed the well-publicized *No Child Level Behind* legislation that gives our schools groundbreaking educational reform; another large-scale national school reform effort was signed by his father, then President George Bush. At an Education Summit held in Charlottesville, Virginia in September of 1989, a set of eight *National Education Goals* was established by all of the nation's governors and the Congress. These goals provided a national framework for education reform and promoted systematic changes needed to ensure equitable educational opportunities and high levels of achievement for all students. Goal five of our National Education Goals pertained specifically to mathematics and science and reading: "By the year 2000, United States students will be the first in the world in mathematics and science achievement" (The National Education Goals Panel, 2003). Each year since, the National Education Goals Panel issued a report to inform the American people on how well we were on track to reach the goals by the targeted year of 2000, three years ago.

Fast forward to the most recent results of the 2003 American College Test's (ACT) science results. The National Science Teachers Association (NSTA), which represents more than 55,000 science educators across the country, believes that the low numbers of students reaching the benchmarks on the Spring ACT science test can be attributed to the growing neglect of K-12 science education in classrooms across the

nation. According to ACT, "students who attain the benchmarks set by the test (a score of 24 for science) have a high probability of completing first-year college courses with a grade of C or higher. Only one-fourth (26%) of 2003 high school graduates earned a score of 24 or higher on the science portion of the test" (National Science Teachers Association, 2003). This percentage is much worse for minority students.

In spite of lofty goals, compared to students from other developed countries, U.S. students continue to rank low in science achievement. According to the Third International Math and Science Study (TIMSS), in 1999, the U.S. ranked 18th out of 38 countries in science and 19th in mathematics (Trends in International Mathematics and Science Study, 2003). The TIMSS report clearly shows that American elementary school children start out doing fairly well in international comparisons, but by the time they finish middle school and complete high school their scores drop dramatically. Moreover, the National Assessment of Educational Progress (NAEP), also known as "the Nation's Report Card" the only nationally representative and continuing assessment of what the country's students know and can do in various subject areas, also shows the same trend in science results.

Like educators throughout the country, at UI&U we are trying to modify and improve our science curriculum in order to help our pre-service teachers. Currently, UI&U has stated goals for science and mathematics education but little ability to ensure that we meet those outcomes. As defined in the UI&U catalog, the desired outcomes within the Nature Science and Mathematics dimension are:

- to emphasize the scientific method as a mode of inquiry
- to gain knowledge of the application of mathematics

- to gain knowledge of the natural and physical worlds (Union Institute, 2000, p. 43)

However, because the university allows transfer credits to satisfy minimum requirements in this dimension, some students may not reach the goals stated in the catalog. Essentially, the university lacks a required foundations course in the natural sciences.

Lack of a specific foundations course creates problems for students that take courses within UI&U. Courses within the Natural Science and Mathematics dimension are individualized, designed by both the faculty member and the student. The university requires faculty members to produce college-level learning contracts (syllabi) with the students, but otherwise does not interfere with the course content. Thus, well-intentioned faculty members may assume that students cover scientific method and philosophy in other courses. As a result, some of our students may graduate without covering scientific method or natural science.

Although Florida State University programs have more structured science offerings than UI&U, they may have problems transmitting scientific method to their pre-service teachers. For example, the University of Florida catalog describes the goal of natural science education as:

> Courses in the natural sciences introduce students to the basic concepts of science and the scientific method and enhance awareness of scientific developments and their impact on society and the environment. This area provides students with an understanding of scientific terms, concepts and theories, and the ability to formulate empirically testable hypotheses derived from the

study of physical processes and living things. (University of Florida, 2003, p. 1-25)

However, the descriptions of the courses listed as requirements give little evidence of the emphasis on scientific method or natural science philosophy. For example, the courses used to meet the science requirements for pre-service teachers include physical science, biological science, earth science, and a liberal arts science course taken together with methods of teaching science. Of the courses that meet these requirements, only the physical science course and the earth science course have descriptions that mention scientific method or process (University of Florida).

Methodology

This year we received a grant from our university to improve science education within our undergraduate program. We hypothesized that it might be necessary to create a science foundations course in order to introduce natural science and scientific method. By emphasizing scientific principles over content, we hoped to help our pre-service teachers become more comfortable with inquiry-based teaching. In order to investigate this hypothesis, we took two tacks. First, we began by reviewing the professional literature, including standards used by state-approved programs in the State of Florida. We compared these to national goals and standards prescribed by, among others, the National Research Council (NRC) of the National Academy of Sciences (NRC, 1996) and American Association for the Advancement of Science (AAAS) (AAAS, 1993). Second, we created a science attitudes survey for our pre-service and in-service teachers (Appendix A). Results of this survey are given below. Finally, we arranged a series of interviews to discuss concerns, challenges, and best practices. We interviewed science

department chairs from private, public, traditional, and nontraditional schools, as well as district administrators responsible for science education in Miami-Dade. Feedback from those individuals is given below. With the results of our surveys and interviews, we then plan to make recommendations to the national faculty for improving our science curriculum.

Results

Attitudes Survey Results

In order to assess attitudes towards science, we created two survey instruments consisting of both open-ended and Likert-scale questions. For our pre-service teachers we surveyed students near the end of their program in order to insure that they had completed a majority of their content courses. For our in-service graduates teaching in elementary schools, we added additional questions that capture information about the teaching experiences of these respondents. In all, we received responses from 18 pre-service teachers and 10 in-service teachers. We believe these surveys measure the confidence of the students teaching in the classroom, their level of interest in science as a subject, and their confidence in explaining the scientific method.

Figure 1 shows student responses when asked about their qualification to teach, organized by content area. Results suggest that the majority of our pre-service teachers believe they are not prepared or qualified to teach life, earth, or physical sciences. Nonetheless, they appear confident in the subject areas of reading/language arts and social studies.

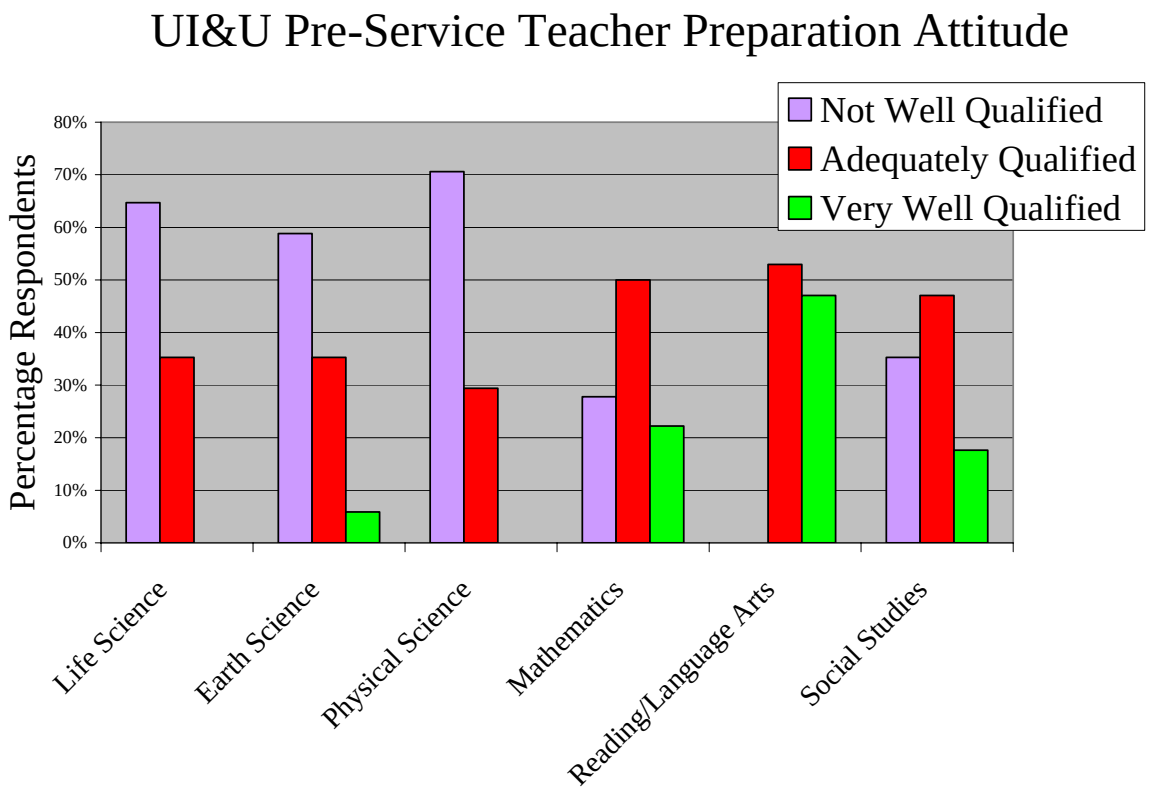

Figure 1. This survey of our preservice teachers shows their perception of their qualifications in core academic subjects. Respondents identified the sciences as their weakest subject areas.

Results from our in-service teachers suggest that as a group they are more confident of their ability to teach science in the elementary school classroom (figure 2). More in-service teachers feel adequately or very well qualified to teach science than the pre-service respondents. Confidence in teaching reading/language arts and social studies is also higher than among our pre-service respondents.

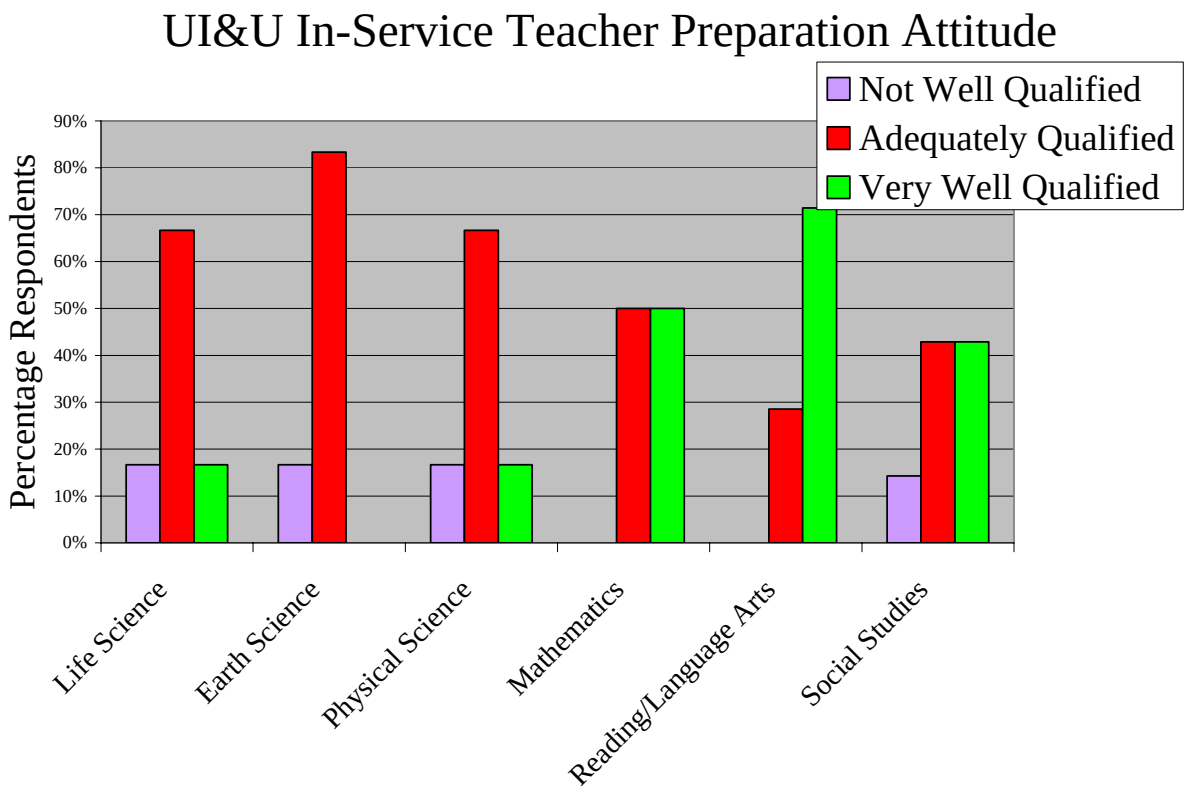

Figure 2. This survey of our in-service teachers indicates they feel more qualified than our pre-service teachers to teach the sciences.

When asked whether they understood the concept of scientific method, both pre-service and in-service teachers responded that they had a moderate understanding of the scientific method (figure 3).

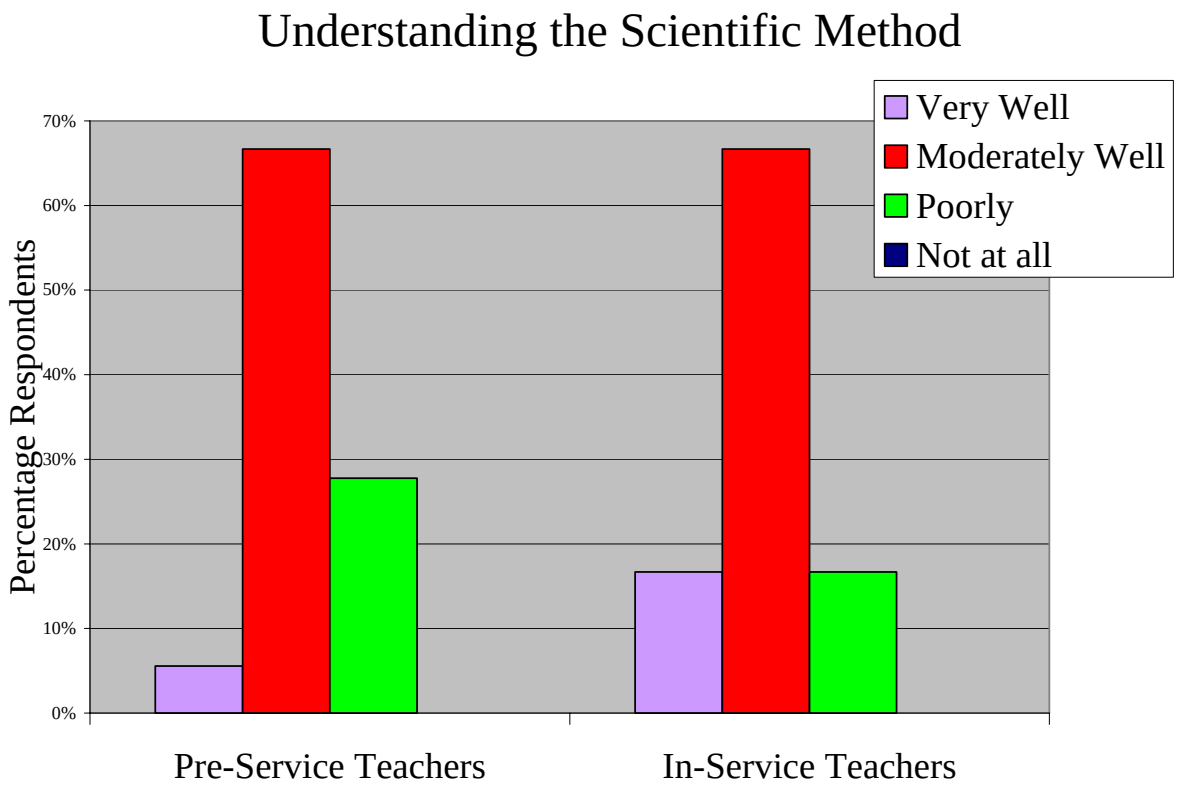

Figure 3. When asked how well they understand the scientific method, our pre-service and in-service teachers gave similar responses. Both groups feel they have an adequate understanding of the scientific method.

Both groups expressed a similar level of interest in science in general with most expressing at least a moderate interest in the subject (figure 4).

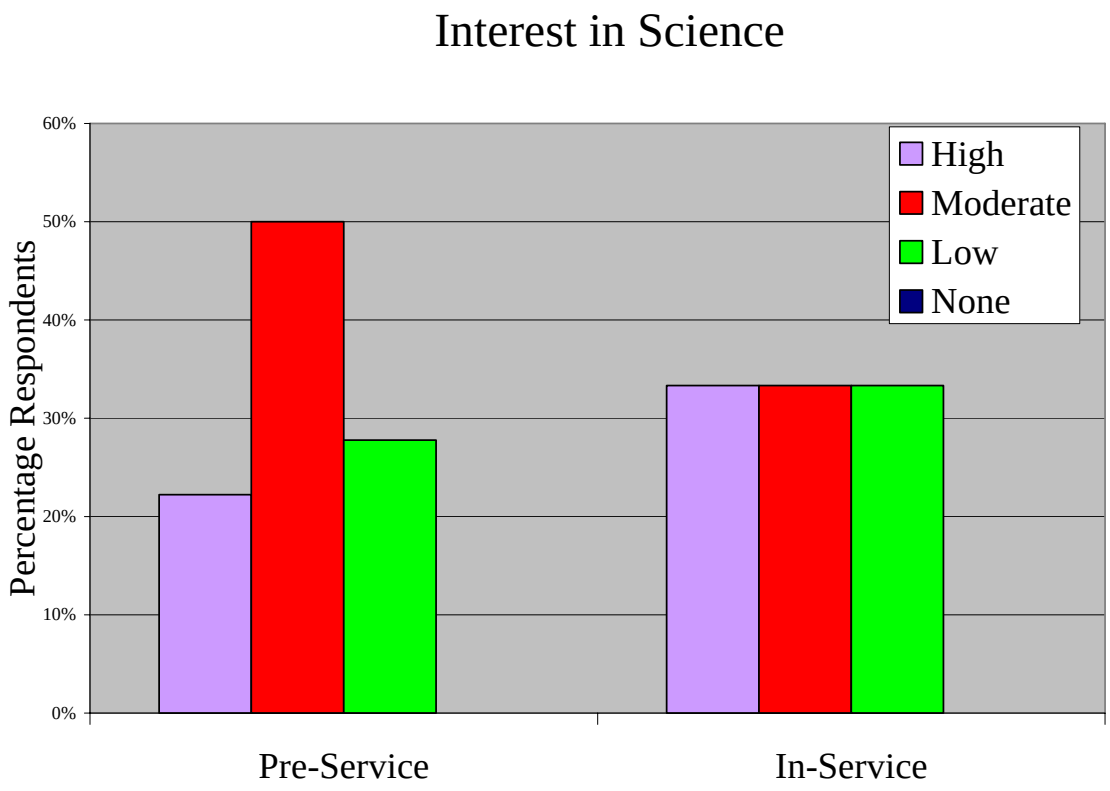

Figure 4. Pre-service and in-service teachers showed varied responses to this question on general interest in science. We were surprised to see responses of high and no interest.

Interviews with Local School District Administrators

We interviewed Dr. Gustavo Loret-de-Mola, the District Science Supervisor for Miami-Dade County Public Schools, the nation's fourth-largest public school system. We asked him eight open-ended questions regarding the efforts of the district to improve education. He emphasized significant areas for improvement include teacher preparation, both in terms of pedagogy and content knowledge. Furthermore, he recognized that most teachers do not feel comfortable teaching science or mathematics. He also added that pre-service teachers need to experience more mock classroom situations and field experience. In contrast, Dr. Susan Mussoline, a Title I Coordinator at a large local

elementary school, felt that most teachers are adequately prepared. Significantly, she identified lack of time for teaching science as the greatest challenge to science education in Miami-Dade County Public Schools.

Other Colleges/Universities

To date, we conducted two 30-minute telephone interviews with 1) Dr. Brenda Moore, Assistant Professor of Biology at Antioch University and 2) Dr. Grenville Draper, Full Professor of Geology and an Undergraduate Academic Advisor at Florida International University. These science professors, although at different stages of their respective academic careers, teach the university's general education science courses. They felt that, overall, the non-science majors considered science irrelevant and approached science with a wide range of preparation. Together, challenges that they identified were large class size, lack of research lab equipment, and overcoming the stereotype that science is "nerdy" and irrelevant.

FIU requires two science courses (each with a lab component) to fulfill the general education science requirements. The two most popular courses in the curriculum were "Introduction to the Earth" and "History of Life" (a biological science course). In contrast, Antioch University requires only one science course and "Practical Nutrition" and "Everybody's Chemistry" are the two most popular courses in its curriculum. Both professors stated that they emphasize scientific method in the classroom but did not know whether their colleagues did so. Nor did they know whether introductory-level science courses in other departments examined scientific method in any detail.

Discussion

As anticipated, our pre-service teachers expressed a lack of confidence in their ability to teach science in the elementary school classroom. However, they expressed a greater than anticipated confidence in their understanding of the scientific method. In contrast, our in-service teachers showed greater confidence in teaching science in the classroom. The source of this increase in confidence is not clear. Perhaps the lack of emphasis on science in the Florida schools has not placed heavy demands on the science teaching skills of these individuals.

We conducted interviews with administrators and faculty from other institutions in order to identify mutual concern as well as best practices. We found that the district science director for Miami-Dade County Public Schools shared our concerns that teachers are often deficient in content and pedagogy in the science education. Our Title I administrator, on the other hand, felt that teachers at her school are adequately prepared for teaching science in the elementary classroom, but conceded that there is little time for teaching science at her school. Possibly these differences in opinion are related to the priorities of these individuals. Clearly the science director has a vested interest in promoting better science education. The Title I administrator, on the other hand, is more interested in insuring high FCAT scores for her school. Because there has been no accountability for science education, there has been little time for teaching science in the elementary classroom. This should change, however, as science achievement will be measured on the FCAT, and used in grading each school, beginning in the 2003-2004 school year.

Our conversations with faculty members from other universities indicate that professors are moving away from the traditional lecture and lab format of science education. Those interviewed indicate a willingness to engage in inquiry-based activities and discussions, even in large classroom settings. This change seems to have as much to do with job satisfaction among professors as it does with good practice. While the professors we spoke to emphasize scientific method, they had little knowledge of what their colleagues covered in other introductory courses. This suggests that universities are not taking steps to coordinate institutional goals and outcomes in the Natural Sciences.

In spite of concerns, many elementary schools have not made science a priority as much as reading, writing, and arithmetic. Furthermore, elementary school teachers have always been considered generalists who teach most, if not all, the school subjects. Consequently, their own knowledge of and comfort level with this particular content area is perhaps also related to how often this subject matter gets taught. While many elementary school (and even middle school) teachers feel insecure with their understanding of scientific concepts, how students learn science is just as important as what they learn.

Here in the State of Florida, a definite "school accountability" state, a science section was added last year to the much-publicized and contentious Florida Comprehensive Assessment Test (FCAT) standardized exam that is administered in grades 3-10 to elementary, middle, and high school students. Simply put, the FCAT exam assesses how well the students have mastered the skills outlined in the state's Sunshine State Standards (SSS). Each of the 67 counties or school districts must ensure that these competencies are being met. Furthermore, the current Bush/Brogan A+ Plan

requires all schools to receive a report card on how well students achieve mastery of the subject area content in the SSS. While 2002-2003 science FCAT scores were not used to calculate the annual letter grades that the schools received, or to student promotion or retention, or even to the awarding of a standard high school diploma, these scores were definitely a clarion call for science education reform.

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Appendix A

Pre-service and In-service Teacher Surveys

Questionnaire for Pre-Service Teachers

1. How do you rate your interest in science?
    a. high
    b. moderate
    c. low
    d. none

2. How well do you understand the concepts of scientific method?
    a. Very well
    b. moderately well
    c. poorly
    d. not at all

3. How many science lessons did you observe as a pre-service teacher?
    a. more than 5
    b. 4 to 5
    c. 2 to 3
    d. one or less

4. Many teachers feel better qualified to teach some subject areas than others. How well qualified do you feel to teach each of the following subjects at the grade level(s) you teach or will teach, whether or not they are currently included in your curriculum? Circle one for each subject.

Life Science	not well qualified	adequately qualified	very well qualified
Earth Science	not well qualified	adequately qualified	very well qualified
Physical Science	not well qualified	adequately qualified	very well qualified
Mathematics	not well qualified	adequately qualified	very well qualified
Reading/Language Arts	not well qualified	adequately qualified	very well qualified
Social Studies	not well qualified	adequately qualified	very well qualified

Questionnaire for In-Service Teachers

1. What grade level are you teaching?

2. Many teachers feel better qualified to teach some subject areas than others. How well qualified do you feel to teach each of the following subjects at the grade level(s) you teach or will teach, whether or not they are currently included in your curriculum? Circle one for each subject.

Life Science	not well qualified	adequately qualified	very well qualified
Earth Science	not well qualified	adequately qualified	very well qualified
Physical Science	not well qualified	adequately qualified	very well qualified
Mathematics	not well qualified	adequately qualified	very well qualified
Reading/Language Arts	not well qualified	adequately qualified	very well qualified
Social Studies	not well qualified	adequately qualified	very well qualified

3. How frequently do you teach science?
    a) more than twice a week
    b) twice a week
    c) once a week
    d) less often than once a week

4. How do you rate your interest in science?
    a) high
    b) moderate
    c) low
    d) none

5. What science courses did you take during college?

6. How well do you understand the concepts of scientific method?
    a. Very well
    b. moderately well
    c. poorly

d. not at all

7. I enjoy teaching science _____.
   a. Very much
   b. moderately
   c. Indifferent
   d. Not at all

8. Have you participated in professional development aimed at improving science education (workshops, etc.)?

9. Have you ever led a class of students using investigative strategies?

10. What do you think is the biggest challenge to teaching science in the classroom?

11. Please rate the following content areas from most important (#1) to least important (#7)

____ Science

____ Mathematics

____ Reading/Language Arts

____ Social Studies

____ Art

____ Music

____ Physical Education

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