AC 2010-1482: TEACHING ENGINEERING TO ELEMENTARY EDUCATION MAJORS

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Teaching Engineering to Elementary Education Majors

The elementary education teacher preparation program at North Carolina State University is a STEM-focused program that requires a course in engineering and technology called Children Design, Invent, Create. For the fall 2009 semester, the course was taught by a faculty member of the College of Engineering from an engineering perspective. Although only one set of assessment data is available, presentation of this data is quite timely, because this course is unique among offerings across the country. The pre-service teachers in the class represented a variety of backgrounds, but generally displayed lower self-efficacy than engineering students of their age. The general lack of understanding of such students with regards to engineering, including the differences and similarities among the various STEM disciplines as well as their own feelings of fear and/or inadequacy when faced with problem solving tasks may represent a significant barrier to the potential recruiting success of future engineering students. This paper will describe the results of self-efficacy assessments, the methods used in presentation of the course material and the ways in which the students were challenged and motivated throughout the course. In addition a partnership with a local elementary school class that illustrated actually classroom learning as a means of modeling lessons will be described.

Introduction

Recent work at the National Academy of Engineering[1] has brought enhanced attention to the status and possibilities of engineering in K-12 formal education. Although many Colleges of Engineering (and other groups) have been involved in outreach to K-12 for years, the inculcation of engineering into K-12 formal education is a more recent development. As discussion evolves about the role engineering may play in the K-12 arena, Colleges of Education continue to prepare teachers for the classroom. Particularly acute is the role of the elementary teacher, who is a generalist with preparation in a broad array of subjects. Some Colleges of Education are beginning to evolve their elementary preparation programs into STEM (science, technology, engineering and mathematics) programs to address the growing demand for more STEM orientation in the K-12 educational space. As these programs are created and implemented, the outstanding question will be how does engineering, which many view as career-oriented as opposed to curriculum oriented, play a role? The tendency is for either a College of Education *OR* a College of Engineering to address engineering education in their degree offerings. The College of Education at North Carolina State University is among the first to develop and engineering-related element to their elementary education program which was developed and implemented in *partnership* with the College of Engineering.

The mission of the Department of Elementary Education at North Carolina State University is to develop teacher leaders who have a deep, general content knowledge with a focus in science and mathematics, expert pedagogy, and a commitment to equity and social justice. Students take required courses in calculus, physics, and biology. They take an additional 9-12 hours of sciences or mathematics and statistics (taught in the respective departments) for a specialization in math or science. During the junior year, when courses are primarily in teaching methods (for example, ELM 310 Children's Thinking and Additive Reasoning and ELM 320 Teaching Science in the Primary Grades), all students take a required course called ELM 340 Children

Design, Create and Invent. This course covers topics from engineering and technology, where technology is defined in the broadest sense.

The approach to teaching technology-related curriculum in this course was based on the NAEP draft framework for technological literacy, "Broadly speaking, technology is any modification of the natural world done to fulfill human needs or desires. This definition sees technology as encompassing the entire human-made world, from the simplest artifacts, such as paper and pencil, to the most complex--buildings and cities, the electric power grid, satellites and the Internet. Furthermore, technology is not just the things that people create. It includes the entire infrastructure needed to design, manufacture, operate and repair technological artifacts, from corporate headquarters and engineering schools to manufacturing plants and distribution networks. Having defined technology broadly in this way, we define technological literacy in an equally broad fashion as the ability to use, understand, and evaluate technology as well as to apply technological concepts and processes to solve problems and reach one's goals. Technological literacy is...a measure of how individuals have mastered the tools they need to participate intelligently and thoughtfully in the world around them." [2] The draft framework for the NAEP assessment breaks technological literacy into three sub-areas, including information and communication technology, design and systems, and technology and society. The importance of this definition lies in a vital error in semantics that has pervaded education so perniciously that it had appeared in congressional legislation such as No Child Left Behind. The K-12 educational arena tends to define technology as the information and communication technology used in the classroom, specifically computers, smartboards, the Internet, etc. This seemingly small mis-definition has led to a widespread misunderstanding of technology that is very limited and limiting. Whether K-12 students should be assessed on their understanding of technology (defined as anything human-made) and what technology is and is not capable of is very contentious, in part due to various groups debating based on differing definitions. If students are not taught to be truly technological literate, they lack the capacity to assess properly issues such as whether to allow irradiated foods, stem cell research, and global climate change. The necessary critical thinking skills to make up for this lack are easily instilled through K-12 engineering education.

The catalog description for the course is: An active, hands-on class where prospective elementary school teachers develop learning activities that children can use to stimulate their imaginations and learn fundamental concepts in science, technology, engineering and mathematics, part of a program leading to licensure in Elementary Education.

The course objectives declare that at the completion of this course, students will be able to:

- Define technology and distinguish between the elements of a STEM educational system

- Explain educational standards that relate to technology and engineering in elementary school
- Distinguish between the natural and the designed world
- Apply the design process to create a new product and solve a problem
- Create standards-based learning activities for elementary age students
- Explain the relationship between science, technology, engineering and mathematics
- Identify the factors that stimulate creativity in children
- Demonstrate capacity in computer-based educational technology
- Explain the impact of technology on society
- Identify the interdisciplinary nature of STEM
- Evaluate the effectiveness of selected engineering and technology-based elementary school programs
- Employ proven practices of teaching using appropriate technology tools, including information technology
- Use developmentally appropriate, culturally relevant, child-centered pedagogy in teaching all young children about technology
- Identify and practice pedagogical techniques that support diversity in the classroom
- Identify and practice integrative teaching strategies

Finally, the specific course topics include:

1. The Nature of Technology
    a. Definitions of technology
    b. Natural world vs. designed world
    c. Science, technology, engineering and mathematics (STEM)
    d. Technology and society
2. K-5 Educational Standards
    a. North Carolina Teaching Standards for All Teachers
    b. North Carolina Elementary Teaching Standards
    c. Standards for Technological Literacy
    d. ISTE-NETS Standards
3. Designing Educational Activities
    a. Creativity in children
    b. Portfolios

    c. Engineering journals
    d. Student learning outcomes
    e. Assessment
4. Engineering Design: Innovation and Invention
    a. Design processes: definitions, parallels
    b. Practicing problem solving and design
    c. Evaluating products and designs
5. The Technological World
    a. Previous definitions
    b. Changing paradigms
6. K-5 Educational Programs
    a. Children's Engineering
    b. Engineering is Elementary
    c. Competitions (Odyssey of the Mind, Science and Technology Fairs, etc.)
    d. Working with parents: STEM nights
7. Educational Grant Writing and Publishing
    a. General grant writing principals
    b. Identifying requirements
    c. Research versus program implementation

Teaching the class

Each class consisted of a short lecture portion followed by an activity portion. The delivery of the class was meant to serve as modeling of various teaching techniques that can be used in the K-5 classroom. During the activities, the instructor modeled the way that the activities should be prepared, introduced and implemented. At times during the activities, class discussion was introduced to discuss how they can be customized to various special populations, such as hearing impaired, gifted, and behaviorally challenged. The students were challenged in their thinking about what K-5 students are capable of doing and understanding.

The college students were asked to keep an engineering notebook during the classes, in which they recorded notes, thoughts, questions, directions from the activities and data or measurements from the activities. Some of the college students were initially resistant to participating in the hands-on activities, making statements about their lack of ability to do well. For example one of the first activities was to design a sail to be tested in class with a fan. The students designed, tested and redesigned their own sails. Asked at the end of the class, several students were surprised at their ability to succeed.

Another important teaching technique that was modeled during the classes was questioning. In conjunction with the inquiry activities, the class instructor used the same kinds of questioning that could be used in the K-5 classroom to encourage the kids to persevere through difficulties and failures. At the conclusion of the activity, the class was asked to reflect on the questioning and to record additional questions and ideas in their engineering notebooks.

The students were instructed in information/communication technology use for teaching in multiple ways. First, the course was conducted using flip videos, the web, a solid projector, and other tools. After the instructor returned from a trip to Cape Kennedy for the ARES 1X launch, she taught a class on rocket design using flip videos taken during her trip and some example NASA-created classroom activities. Next, an elementary school science specialist had some of his classes, ranging from grades 3-5, record a discussion of how they have used smart boards and flip videos in their science classes. This video was used as the basis of a class discussion and writing assignment. Finally, a portion of the final exam for the course consisted of answering questions about videos of the instructor implementing various activities in actual K-5 classrooms.

One of the semester-long assignments was for the students to choose children's book and design an activity related to engineering to do with the K-2 classroom to which they were assigned for the semester. They wrote a proposal for the activity, then after instructor feedback, wrote a full lesson plan to show to their partner teachers. After they read their story and implemented their activity in class, the college students wrote a summary of how the activity had gone and whether they would do anything differently the next time. Some of the college students reported that either they or their partner teachers were unsure about whether the K-2 students would be able to complete the activity. (This was the primary reason for the proposal review process.)

Assessment

The students were asked to report on various areas of confidence and knowledge both before and after the class. Three of the questions were asked in the negative. Figure 1 shows the average rating on a five point Lickert scale (1=disagree strongly, 5=agree strongly)for each of the statements,

- I am confident in my science knowledge
- I am confident in my understanding of technology
- I am confident that I know what engineering is
- **I am good at doing hands-on activities (**The three statements that were originally in the negative are reversed for the purposes of data reporting, in other words, a 2 becomes a 4, etc.**)**
- I am confident that I can do hands-on activities in a K-2 class
- I am confident that I can do hands-on activities in a 3-5 class
- **I will have time for hands-on activities in my classroom**
- I am confident in my ability to do problem solving
- **I am confident that I can teach my class to problem solve**
- I am confident of my ability to teach different types of children
- The engineering design process can help me teach the standard course of study (SCOS) to my class

First year engineering students tend to be much more confident in their knowledge of science, technology and engineering, which is to be expected.

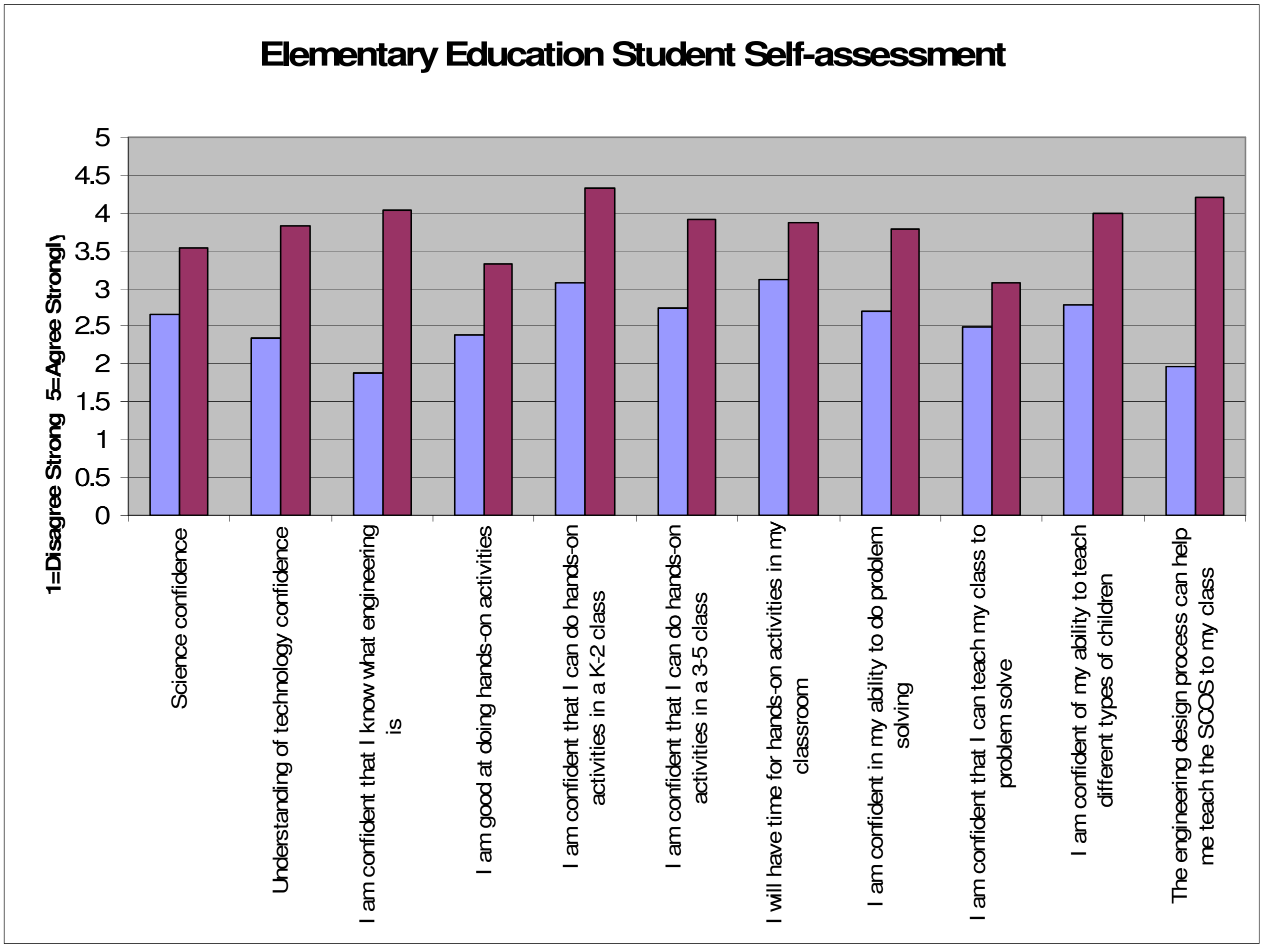

Figure 1: Education student self-assessment of confidence and knowledge

Two additional questions asked: "Do you feel that engineering and technology can be used to enhance learning in elementary school? Explain," and whether they were surprised at how well the activity that they did in their individual K-2 classes went. The average Likert score for this question was 4. Some sample answers to the first question show that the students did, in fact, learn more than the instructor hoped.

"Yes; it allows children to see that there is not just one way to solve a problem and it is okay to question the things around you."

"Yes, they involve multiple subjects which is how we want to teach."

Of the answers to this question, twenty-seven out of twenty-eight were along these lines. One indicated that there would not be time in the classroom for activities.

Conclusions

This first implementation of the ELM340 class produced interested lessons about how elementary education students view themselves, engineering, science and technology. They were somewhat resistant to doing activities, and displayed much lower confidence in their abilities in the classroom than expected. Continued teaching of this unique course under the unique partnership of the Colleges of Engineering and Education will likely produce many more interesting results.

Bibliography

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