WIP: Introducing engineering principles into PreK-6 through a service learning partnership

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Abstract

We report on an interdisciplinary project in which pre-service teachers and engineering students worked collaboratively to design and deliver engineering lessons for elementary school students. We describe the approach and preliminary results for two participating populations: freshmen engineering students and pre-service teachers. Specifically, we explored the following research questions: 1) Does the development and implementation of engineering lessons for elementary students affect education students' a) knowledge of engineering; b) beliefs about the incorporation of engineering in elementary school instruction; and c) comfort and motivation to teach engineering? 2) What do education and engineering students perceive as the benefits and challenges of collaborating to develop and teach engineering lessons to elementary students, and how do they characterize the impact on the elementary students? We provide preliminary findings and discuss the results.

Keywords

Engineering education, K-12 education, service learning, collaborative learning

Introduction and Background

This work in progress paper reports on an interdisciplinary project in which pre-service teachers and undergraduate engineering students worked collaboratively to design and deliver engineering lessons for elementary school students. The project has three immediate objectives: 1) increase elementary school students' exposure to and interest in engineering; 2) increase pre-service teachers' confidence with and support for teaching engineering in elementary schools; and 3) improve engineering students' general engineering knowledge and likelihood of remaining in engineering, all with the long-term goal of improving the recruitment and retention of women and minority students in engineering. This paper describes the approach and reports preliminary results of the lesson planning and implementation. Specifically, we explore the following research questions:

1. Does the development and implementation of engineering lessons for elementary students affect education students' a) knowledge of engineering; b) beliefs about the incorporation of engineering in elementary school instruction; and c) comfort and motivation to teach engineering?
2. What do education and engineering students perceive as the benefits and challenges of collaborating to develop and teach engineering lessons to elementary students? How do they characterize the impact on the elementary students?

Project Description

Students from a 100-level mechanical engineering course (n=43) and education students from a 300 level pre-service teaching program (n=53) at Old Dominion University worked together in teams of four to five. Students collaborated to develop and teach a lesson on an engineering-related topic to small groups elementary school students. Each team developed a lesson covering a specific topic of their choice within a range of student-selected themes including cars, aircraft and spacecraft, design and manufacturing, energy, and prosthetics. The specific audience was 4th graders from a local public school in Norfolk, Virginia.

The engineering lessons followed the BSCS 5E instructional model[1,2],which has been proven effective in teaching science.[3,4] The 5Es are phases of an inquiry-based lesson in which teachers 1) *engage* students by asking questions that generate curiosity and probe background knowledge; allow students to 2) *explore* potential answers through hands-on investigation; 3) *explain* scientific concepts by building upon the students' observations; invite students to 4) *extend* their learning by applying the concepts to new problems; and finally 5) *evaluate* what students have learned.

To facilitate collaboration, each team used a web-based tool tested and developed using prior NSF support by one of the authors. The tool supports key processes such as goal alignment, planning, progress monitoring and communication, and includes features such as a remote meeting room, team charter, project planning tool, data repository, and a task tracker. Results to date have shown that the tool has a significant positive impact on team processes and outcomes.[5,6]

Research Methodology

On November 10, 2016, twenty groups of students delivered 50-minute engineering lessons to fourth graders (https://www.youtube.com/watch?v=PXyUp38bwC8). Two data sources were used to examine the impact of the lessons on the participating college students. A pre-post quasi-experimental approach was used to evaluate the education students' attitudes towards teaching engineering in elementary school. Three variables were measured in an online survey: Beliefs about Including Engineering in Elementary School (BIEES)(5 items); Comfort Teaching Engineering (CTE) (5 items); and Motivation to Teach Engineering (MTE) (3 items). All items were based on a 5-point Likert scale anchored by strongly disagree and strongly agree. In the post-test survey, students were also asked to describe the most beneficial aspect of the project.

Following the project each student wrote a reflection summarizing their lesson, the 4th graders' reactions to the lesson, and their perceptions of the project's impact on them. One reflection paper from each project team was selected for analysis, ten authored by education students, and ten by engineering students. This paper reports the preliminary analysis of these data sources.

Preliminary Analysis and Results

The final quantitative data sample included 16 complete paired data sets. To assess the impact of the project on the pre-service teachers' attitudes a paired t-test comparison of the variables of interest before and after the project was implemented. Results indicated that the lesson

implementation had a positive impact on pre-service teachers' Comfort Teaching Engineering (CTE). No significant impact was seen in the BIEES and MTE variables (see Table 1).

Table 1. T-test results

		Mean	N	Std. Dev.	P-value
Pair 1	BIEES_PRE_AVG	3.8250	16	.551	.25
	BIEES_POST_AVG	3.9500	16	.549	
Pair 2	CTE_PRE_AVG	3.1375	16	.660	.05
	CTE_POST_AVG	3.4375	16	.811	
Pair 3	MTE_PRE_AVG	3.8889	15	.544	.32
	MTE_POST_AVG	4.0444	15	.628	

The qualitative post-test survey item (N=49) was inductively coded using a grounded theory approach. Six themes emerged in the benefits described by students. Both groups of students appreciated the opportunity to interact with children (17). Many expressed increased confidence and expertise in engineering (9) and several students noted the value of exposing children to engineering (7). A number of students named benefits from collaborating with others (5). Others described satisfaction from seeing children excited about learning (5) and shared a new appreciation for hands-on learning (5).

A sample of twenty individual student reflection papers were analyzed to for evidence of : 1) student knowledge of engineering; 2) student characterization of the lessons' impact on the 4th graders, 3) student perceptions of the challenges and benefits of the project; and 4) student attitudes toward teaching engineering.

Almost all students clearly articulated the engineering concepts their groups taught in their lessons, and the few that did not, wrote very general, rather than incorrect, statements. The college students universally characterized the 4th graders' responses as very positive, noting their enthusiasm for the lessons, especially the hands-on components. Many reported surprise at the 4th graders' prior knowledge about engineering and their ability to quickly grasp the presented concepts. The students used summaries of short quizzes they developed to evaluate the success of their lessons and a common 3-question interest in engineering survey to describe the academic impact of their lessons. They overwhelmingly reported that the 4th graders mastered the intended concepts and showed a high degree of interest in engineering.

The benefits discussed in the reflections paralleled those mentioned in the post-test survey. The students appreciated the opportunity to interact with children and to try out teaching. Many reported being pleasantly surprised with how well their team worked together, although setting up meeting times, communication, and work distribution were still reported as challenges. A couple students shared new appreciation for compromise, for example "it was a good experience to work with other people because that is an important skill for the future, and I learned that many ideas that I might have not thought about we could come up [with] as a group, and any

challenges could be overcome." Others reported greater appreciation for the challenging, iterative process of designing a lesson and the resources need to teach it. For example, one student wrote: "I did learn that engineering takes work to perfect something. I ran through five different design ideas when building a car for the kids. It was hard to get right, but eventually I had the one breakthrough that put me over the top"; while another said: "it is not a single draft lesson, because once you make it, you will definitely have to revise it until it is effective." One student succinctly captured her experience, "I learned that teaching is actually harder than it looks."

All students stated that engineering should be taught in elementary schools. Most suggested a limited introduction that would pique student interest. They also suggested engineering would help children apply science skills and engage creative thinking. There were mixed reports on the confidence and capability of elementary school teachers to teach engineering, but there was appreciation for professional development opportunities that could help teachers feel more confident. One student stated: "To be honest, I was a little concerned about teaching engineering concepts to fourth graders at first; however, through research and knowledge from others I learned so much and became more comfortable with the subject of engineering. I think that having this in the education curriculum at ODU and other colleges could prepare future teachers and make them feel more comfortable about teaching the amazing wonders of engineering."

Conclusion

This paper reported on a unique project aimed at introducing engineering in the pre-K to 6 curriculum through a partnership between engineering and education students and faculty. The project engaged engineering students in a meaningful service learning activity while exposing them to pedagogical methods that are not typically part of the engineering curriculum. For education students, the project provided exposure to both engineering concepts and engineering students, which were also outside of their typical academic experience. This project exposed future teachers to engineering material in a low threatening environment by developing lessons through collaboration with student peers, while also engaging elementary students into understanding engineering concepts. This meaningful exchange was shown to increase the education students' confidence with engineering and, accordingly the potential to increase their willingness to teach engineering concepts in the future.

The comment illuminating the parallels between designing a lesson and designing a product validates the synergistic benefits of bringing these two groups together to work on a common assignment. As students are designing their lessons they are simultaneously learning about engineering and teaching, as well as about collaborating, communicating, and compromising with others. That this is done in the context of helping recruit and retain more students in engineering, makes it all the more promising.

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