2009

A Case Study of the Implementation of an Engineering Program into a High School Technology Education Classroom

Steven Shumway
Brigham Young University

Geoff Wright
Brigham Young University

Research

In

Engineering and Technology Education

ncete™

NATIONAL CENTER FOR ENGINEERING AND TECHNOLOGY EDUCATION

This material is based on work supported by the National Science Foundation Under Grant No. ESI-0426421

A Case Study of the Implementation of an Engineering Program into a High School Technology Education Classroom

Steven Shumway and Geoff Wright
Brigham Young University

Study Objectives

Using a case study format, our objective was to collect data related to the following research questions:

- What criteria do teachers and districts use when selecting engineering design experiences for infusion into high school classes and which of these criteria are most effective?
- What issues, opportunities, and constraints do teachers confront as they infuse engineering concepts into technology education?

Specifically, we conducted interviews and classroom observations to collect data to answer these specific questions:

- What criteria were used by the teacher and district when developing a rationale for the high school engineering course?
- What standards (STL, ABET, Science) or objectives were used when designing the course?
- Were the curriculum materials teacher-developed, selected from a national set of materials, or provided by a vendor?
- Did the teacher or district officials know about already developed curriculum packages that could have been used; if so, did they choose to use these curriculum packages?
- Is the course based on clear objectives or is it comprised of a set of "cool" activities?
- Are the engineering activities chosen for the course different from the technology education activities that have been used previously?
- Do engineering activities involve constraints, optimization, and predictive analysis, or do students rely on trial and error to develop solutions to problems?
- Did the teacher teach a balance of engineering concepts from each domain, (i.e., electrical, mechanical, chemical, civil) or did he mostly cover the concepts that he was most comfortable with?
- Were there any pre-requisites (math, science, technical courses) that students should have taken to help them be successful in this course?
- How did the teacher assess how well the students truly met the standards and objectives?
- What help did the teacher receive from the district or state office of education in regard to the course?
- What other obstacles did the teacher faced as he taught the course?
    a. Obstacles in recruitment?
    b. Obstacles in working with Utah State Office of Education (USOE) with course codes required for funding, and credit requirements?
    c. Obstacles with the facilities, equipment, supplies, or curriculum?
    d. Obstacles with funding?
    e. Obstacles with teacher certification (USOE)?
    f. Obstacles with student levels of knowledge?
        i. Math concepts
        ii. Science concepts
        iii. Ability to problem solve
        iv. Motivation levels of students

- Did the teacher feel that he knew enough about engineering principles to teach the class?
- Finally, since the teacher in this study was a participant in the Year 1 NCETE engineering design workshops, we wanted to determine what impact, if any, that workshop had on the teacher's desire and ability to teach engineering concepts at the high school level.

Findings and Discussion

The purpose of this section is to summarize and discuss the findings of the study. This will be done by presenting the findings, and then discussing the findings' impact and influence on technology engineering education.

While our initial research objectives were to: a) determine what criteria the teachers and districts use when selecting engineering design experiences for infusion into high school classes experiences and which of these criteria are most effective; and b) determine what issues, opportunities, and constraints teachers confront as they change their approach to teaching to infuse engineering concepts into technology education, we believe the findings from the interview and observations provide a broader understanding of adopting or making the transition from a traditional technology education program to a focused contemporary technology and engineering education program. Although this was not our initial research objective, we feel this is an important finding for the field of technology and engineering education because currently many of the schools with technology related programs nationwide are either considering adopting new curricula to ensure that their programs stay current and relative, or are cutting technology programs [1 2 3].

Finding 1: *It is imperative that the teacher have a passion for technology beyond mere subject expertise and be willing to include contemporary techniques, tools, processes, and issues in the course.*
During the interviews and observations it was obvious that the teacher's interest in technology education was facilitating his willingness and ability to incorporate engineering curriculum into the technology education program. In talking with the teacher it was discovered not only had he been teaching technology education classes for over 12 years, but had graduated with a bachelors in technology education, and later completed a masters also in technology education. Additionally he is certified by AAS in drafting and has T & I certificates for drafting and masonry. The teacher's background and experience greatly facilitated his enthusiasm and capability to evolve his program toward an engineering focus. Notwithstanding his training and background in technology education, he demonstrated other attributes that facilitated the transfer. He mentioned during his interviews that because he had observed great potential for deeper and exploratory learning in the engineering fields, he had started to develop his own curriculum based upon personal interests, issues he was observing in the economy, and various mechanical, robotic, and civil advancements he had read and heard about. In light of his own personal interest, he eventually started to develop his program to include more engineering related projects. However, it wasn't until he attended a few professional development activities specifically focused on creating an engineering program that he realized the need and urgency to do so rapidly. Despite recognizing the need and wanting to make the transition, he did face a few challenges that he had to address to ensure the transfer from a traditional technology education program to a contemporary technology and engineering education program was effective. These challenges are outlined in Findings 2, 3, and 4.

Finding 2: *Teachers need to ensure their administrators understand the need to have a contemporary technology education program focused on engineering.*

As soon as the teacher recognized the need and urgency to make the transfer from a traditional technology education program to a contemporary technology and engineering focused education program, the teacher started to put together a proposal for his site administrator. As he gathered data and information for the

proposal he realized that he also needed district support to ensure that the transfer was effective and fully supported. Consequently he created a PowerPoint presentation outlining why the transfer was important, how it would be accomplished, how the students would benefit, what the learning outcomes would be, and what the curriculum would look like. He showed the presentation to the district personnel involved in technology education and also to his principal; consequently both parties were impressed and supportive of the transfer. The teacher mentioned that his site administration permitted that two of his classes to be designated as technology engineering courses, and additionally provided him some time and funding to attend professional development activities which provided some of the training the teacher felt he needed to facilitate the transfer. The district also helped the teacher find the Utah Classification of Instructional Programs (CIP) codes for the classes, which officially recognized the two new classes as academic subjects – consequently providing funding for the program. Although the support of both the site administrator and district were helpful, when the state officially recognized technology and engineering education as a core subject area (giving technology and engineering classes science credit), that was the moment when the teacher knew that the transfer from a traditional technology education program to a contemporary technology and engineering program would work, be worth the effort, and pay wonderful dividends. One of the particular dividends was providing an alternative course option for science credit. The new technology and engineering courses would provide an experiential, practical alternative for students interested in applied science rather than traditional biology and chemistry. The teacher reported, "I was hoping for 20-30 students, instead, I had 61 sign up."

Finding 3: *Teachers need to be aware of contemporary technology and engineering education issues, trends, processes, techniques, standards, and tools.*
Although the teacher had approval, and was enthusiastic about the change, he knew he had a lot of work to do before having a highly functional technology and engineering program. One of the most obvious dilemmas which he faced was figuring out exactly what he needed to teach, and then making sure he could teach those things, meaning that he was certified, and that he had the understanding and content knowledge to do so.

The teacher initially started developing curriculum based on what he knew, what he was interested in, and according to the professional development he had experienced. He recognized this might be a limited approach, but he reported that he wasn't aware of any other options. When he was asked where he was obtaining his resources and curriculum, he reported that he developed most of his activities from collaborating with a local university professor who was interested in technology engineering education. When he was asked if he used a particular set of standards, he said he checked the state office of education website for related standards, but found that nothing really fit, except for 3D modeling. Then when he was asked about other sources and standards he could use for his curriculum, he reported that he had heard of Project Lead the Way, but didn't know much about it, and that he believed ITEA had some curriculum or resources, but didn't know where to get their information. He wondered what the costs would be for using resources from either of these places. Eventually, after some assistance from the local university and from working with the district personnel responsible for technology education, he was able to map some of the curriculum he had decided to use with various national standards for technological literacy. In mapping his curriculum, the teacher also modified and added to the content he had initially anticipated teaching. Eventually the teacher decided on the content for the technology and engineering courses would include: digital electronics (binary notation, logic gates, protoboarding and circuit simulation software); micro controllers (i.e., basic stamp, legoMindstorms); mechanical design (i.e., SolidWorks, 3D derby); conceptual architectural design (i.e., 3D drawings and renderings using googleSketchup); and structural design (i.e., WestPoint Bridge Builder).

Although the interviews and observations suggest the teacher was not aware of the new standards current directions of technology education, or existing technology and engineering education curriculum, he was able to create a curriculum which accomplished some of the learning objectives outlined by many of the

nationally recognized technology and engineering education movements (i.e., Project Lead the Way). The teacher did report, however, that had he been more aware of the current trends and standards of technology education, he felt that the transition, and especially his curriculum, would have been more efficient.

Finding 4: *There will be obstacles when making the transition to (or adopting a new) technology and engineering program, however, they are limited to issues of facilities, administrative concerns, teacher training, and pedagogical issues.*

Facilities

The teacher reported that although he believed he had sufficient tools and equipment to start teaching an engineering focused curriculum, he felt that to have a successful program he would need additional tools, equipment, and supplies. He stated, "My current facility is inadequate for the types of activities that I would like to do." Additionally he shared,

> "My biggest problem was that there were conflicts over equipment and supplies between the two year-long classes. I did not have enough supplies (i.e., LegoMindstorm kits) for both classes. I tried to alternate activities between classes but the classes completed the activity in varying amounts of time which caused additional problems."

The teacher suggested that he saw the potential his classroom had, especially after visiting other technology and engineering high school labs around the state, but felt that it would take a lot of funding and several years to develop what many of them had. He did however, believe that with his move into the new school this next year, that he would have a better lab and classroom because the administrator had asked him what type of space he could use, and had provided him extra budget to purchase a few more saws, sanders, and the like.

Administrative Concerns

The administrative concerns that posed some obstacles involved issues working with state, district, and site administrators. Specially, the teacher suggested that one of the most difficult parts of developing a program with an engineering focus concerned developing the right learning objectives so that they matched existing state CIP codes. The teacher said in reference to the CIP codes, "It was very difficult to find the correct CIP codes to use."

Although we anticipated that there might be some administrative concerns surrounding issues of funding, the teacher said that he understood his budget would be limited because of economic and other budgetary constraints, but did admit he was pleased with how much administrative support he did receive in terms of new equipment and supplies for this next year when he moves into his new school. In fact, he reported that his administrator even asked for his input on how he would like his new classroom and lab to be organized. Finally, although the teacher did not report being frustrated by not having any state or district support for his lab, he was surprised to learn that grant monies, which he was qualified to receive, are available both from his district and from the state,

Teacher Training and Pedagogical Concerns

By far the largest categories of obstacles the teacher reported as posing difficulties for incorporating engineering into his program concerned issues of curriculum, content, instructional activities, and assessment. The teacher believes that most of these concerns result from a personal need to further develop his own understanding of the engineering design process, math and science content knowledge, an understanding of how to develop other activities which would better use the equipment and supplies he had, and then how to assess student learning. In regard to these concerns the teacher reported, "A teacher's personal knowledge is a large obstacle, even if you have curriculum given to you, the teacher needs to go through the curriculum before teaching it in order to be effective."

Curriculum and Content

The teacher's primary concern regarding making the transition from teaching the drafting classes he had been doing for the majority of his teaching career, to teaching an engineering focused curriculum was making sure he had the content knowledge to do so. Concerning this he said, "I am not a science guy – I am sure there are concepts in the curriculum - I just don't want to take the time to map them out…most of the activities in the class do not require the students to conduct a lot of mathematical analysis." This was by design as the teacher was not comfortable, nor excited by a heavy math involvement or emphasis. When we further asked the teacher about this he said he didn't feel very confident teaching complex science and math related problems or equations. He did admit that he knew it would be important to include math and science in the class, but he felt that he would need to "brush up" on his math and science skills before significantly adding it to his curriculum. Additionally, in relation to this issue, he said that he did not believe many of his students would be ready for an engineering curriculum that involved much math or science. He said that he has a "Wide range of skill level in the class, from college bound students to special education students." Because of this he worries that bringing in too complex of problems might "scare" off some of the students who would normally benefit from an experiential hands-on course such as this.

A secondary concern regarding curriculum was mapping out how long each topic should be covered. He said that, "In teaching a class like this for the first time I didn't know how long it will take the teacher and the class to complete a unit of instruction." He said that if he could "try out" the curriculum or get additional feedback from others who are using a similar curriculum he would be better able to plan his instructional efforts.

Instructional Activities

Because of the teacher's 12 years of teaching technology education, the teacher felt confident that he would be able to create instructional activities which would meet the demands of an engineering focused curriculum; however, the interviews and observations revealed the teacher faced a few obstacles in trying to do so. The first issue resulted from student apathy. He found that many of the students came in thinking they were going to just be doing CAD drawings of simple homes; however, when they were challenged with various engineering problems, the teacher shared, "Students seem to want to be spoon fed everything and do not want to try and solve the problem on their own… students seem not to be adept at problem solving. They wanted the answers given to them. Often they would face a problem and give up." The teacher believed this problem stemmed from the students' unfamiliarity with the new curriculum and different type of learning (i.e., inquiry based learning and experiential activities). The teacher suggested that in order to address this problem he needed to take more time teaching and modeling for the students how to work with the different tools, supplies, and projects to accomplish the challenging tasks.. Additionally, he thought that he needed to help the students develop a deeper understanding of basic math and physics, and a foundational ability to use tools and materials in order for them to be successful.

The second issue the teacher described related to instructional activities was coming up with activities that he had sufficient tools and supplies to implement. The teacher had visited several other technology and engineering programs, and had participated in various professional development activities focused on technology and engineering, but when he tried to do many of the activities he had observed or learned, he quickly realized he didn't have enough supplies or equipment. In regard to this he said, "My biggest problem with this was that I had two year-long classes and there were equipment and supplies conflicts between the two classes. I did not have enough supplies for both classes. I tried to alternate activities between classes but the classes completed the activity in varying amounts of time which caused additional problems." The teacher did report that he believes this issue can be resolved by planning different activities, having term or semester classes instead of year long classes, and by having additional equipment and supplies.

Assessment

The teacher reported that one of his primary pedagogical concerns was being able to assess student learning. Concerning this he said, "Coming up with assessment was a big obstacle… knowing what to assess is a huge question (i.e., programming skills, knowledge of engineering design process and content)." Additionally, he shared, "I didn't really have any assessments developed before teaching the class… I am still in the process." The observations and interviews suggested that although he doesn't feel very confident with the assessment he has currently developed, it appears he is seeking additional resources to further develop his student assessments. Finally, the teacher also shared that he plans on using the assessments to help him evaluate his teaching efforts and ultimately to shape the direction of the program.

Conclusion

Our initial research objectives were to: a) determine what criteria the teachers and districts use when selecting engineering design experiences for infusion into high school classes and which of these criteria are most effective; and b) determine what issues, opportunities, and constraints teachers confront as they change their approach to teaching to infuse engineering concepts into technology education. In regard to our initial research objective, the findings of the study suggest that teachers who are in the transition from teaching traditional technology education to teaching contemporary technology and engineering focused education classes will need professional development to help familiarize them with the current technology and engineering learning objectives, standards, trends, issues, and curriculum. Additionally they will need administrative support from both site and district administrators for training, equipment, and supplies. In light of these findings, we feel that the national efforts of ITEA and other organizations need to be better promoted in order to educate teachers about the current trends, issues, standards, and possible grants in the technology and engineering arena.

References

1. Douglas, J, Iversen, E. & Kalyandurg, C (2004). *Engineering in the K-12 classroom: An analysis of current practices and guidelines for the future*. Washington, DC: American Society of Engineering Education.
2. McAlister, B., Hacker, M., & Tiala, S. (2008). Engineering content and the technology education curriculum. In Custer, R. L., & Erekson, T.L. (Eds). *Engineering and technology education*. Woodland Hills, CA: Glencoe/McGraw-Hill. (pp. 77-101).
3. Welty, K., Katehi, L., Pearson, G., & Feder, M. (2008). *Analysis of K-12 engineering education curriculum in the United States: A preliminary report.* Proceedings of the 115th Annual ASEE Conference and Exhibition, Pittsburg, PA, June 22-25, 2008