Journal of STEM Teacher Education

Volume 46
Issue 2 *JITE Fall*

Article 10

September 2009

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Recommended Citation

Kaluf, Kevin and Harris, Kara S. (2009) "At Issue: Students Must Understand Both Theory and Practice," *Journal of STEM Teacher Education*: Vol. 46 : Iss. 2 , Article 10.
Available at: http://ir.library.illinoisstate.edu/jste/vol46/iss2/10

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Students Must Understand Both Theory and Practice in Engineering/Technology Education

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The name of our profession has gone through many name changes throughout the years. From "Manual Training" to "Industrial Arts" to "Industrial Technology," the names have changed, but the goals have always been the same: to teach students how to become more technologically literate in an ever-changing world, while gaining skills that will help them to become productive citizens in this changing world. The inclusion of pre-engineering education in K-12 technology education programs has become more prevalent in the last decade because of the shortage of qualified students who graduate with engineering and engineering technology degrees (PLTW, 2007). This is now leading many state curriculums and university programs to begin using the name "Engineering/Technology Education" in reference to their technology education programs. In a recent International Technology Education Association (ITEA) poll, 30 % of 829 technology education-related responders said that their teaching field in their state has either changed names in the last two years, or was contemplating changing its name in the near future (ITEA, 2008). The U.S. Department of Labor predicts that the global economy will be short 15 million technical workers by 2020 (Opsahl, 2006). It is the job of high school technology programs to help prepare students for successful college experiences in engineering and engineering technology.

Pre-engineering education involves coursework in subjects that draw content from the work of engineers and promises engineering and technology careers as potential futures of the students who pursue these courses (Lewis, 2004). Including pre-engineering courses in current technology education programs gives students a small taste of many of the possible problems, situations, and case studies that many engineers encounter every day. Pre-engineering courses should address technical content from a design and modeling approach, where engineering analysis is an important element along with string connections to mathematics and science (Burghardt, 2006). Teaching pre-engineering content in this way may differ from what may be seen in traditional Technology Education programs. Many Engineering/Technology Education educators could find themselves concentrating on teaching all their students the theories behind technology education, and not giving them adequate career skill immersion. Some could find themselves trying to create future engineers, while forgetting about those students who aren't interested in careers in technology or engineering. Engineering/Technology Education programs and teachers must remember to incorporate the theory behind E/TE to all their students to help them become more technologically literate, but also let them get hands-on practice that will help those with the propensity to excel in the engineering or engineering technology fields.

Understanding Engineering/Technology Education Theory

Technological Literacy can be described as the history of technology in society, the positive and negative impacts of it, and the discussion of technology from a basic "how it works" perspective (ITEA, 2000/2002). Engineering/Technology Education's role in our schools is to prepare students to be technology literate for our technological society by understanding the *need* to be technologically literate, since technology will always be a part of all aspects our lives including education, home, health, career, and community. Students should also begin developing an understanding for experiences with problem solving skills, and begin to integrate the core subjects of math, science, language arts, social studies, physical education, and art knowledge and skills together. It is imperative that new K-12 pre-engineering programs include these important concepts as a part of their every day offerings, because in many cases, students are either taking these courses in lieu of the traditional technology education courses offered at their school, or schools have replaced those traditional courses with pre-engineering courses (Lewis, 2004). It is the responsibility of the instructors and the schools to provide these students with the technological literacy they need in their pre-engineering courses, even if they are not going to pursue engineering as a future career. Technology education is for all students. Technological literacy should be understood as the ability to use, manage, understand, and evaluate all technology, not just "engineering technology." These students who decide that engineering is not for them must still be given the opportunities to engage in the basic theory behind Engineering/Technology Education, and that is to learn about and experience technological literacy to become more productive citizens.

Engineering/Technology Educators need to model the basic technology skills that many others may take for granted that students already know. Visual communication skills, such as sketching, basic prototyping using construction and/or manufacturing skills, power and energy knowledge, and fundamental computer skills are extremely important concepts which all students should be exposed to, and in many cases it falls into the hands of the high school engineering/technology education instructor to either teach these skills, or help expand on the rudimentary skills the students have already learned in middle school. Successful engineering/technology education requires a fundamental understanding of technology, and the impact it has had on our society. Having students who have had previous courses in technology, and are familiar with many of the terms and situations the instructor is expanding on only makes the E/TE educator's job easier. If they are lacking in those skills, it becomes the job of the E/TE instructor to show students the technology theories and concepts they need, because it is their job to prepare all students for their submersion into an ever-changing world, regardless of what career path they choose to take.

Understanding Engineering/Technology Education Practice

For those students who are taking Engineering/Technology Education courses as a pathway to engineering or engineering technology careers, acquiring technological literacy, while important, may not be enough to satisfy their desire for specific skills they will want for university work. This is where the practical side of E/TE can become very important to many students. Engineering education differs from technology education in the inclusion of engineering analysis. Engineers want to develop physical models, and then create mathematical models that describe these physical models (Burghardt, 2006). Students who plan to go to higher education to study engineering should have this experience in analysis, amongst the engineering career concepts they encounter, so they are more familiar with it before their entrance into a university setting. *Project Lead The Way Principles of Engineering* instructor D. Martin (personal communication, 3/26/08) of Hobart High School in Indiana, states:

> In past courses, I have had many projects where "building and testing" the models made were the only modeling approaches used for successful project completion. Many student trial-and-error sessions were sometimes required. Usually, no "engineering" went into the designing of solutions. Now, in my Principles of Engineering course, we use computer-based mathematical modeling, which has opened up new areas of project success. While doing essentially the same project, students are now using mathematical formulas and design software, where math and modeling are now playing a huge role in the initial design process. Students are now able to predict the behavior of their design and understand the factors that ultimately positively or negatively affect the performance of their design.

Students participating in pre-engineering coursework come to see what being an engineering technologist entails. As John Runkle and Calvin Woodward pushed the concept of students gaining career skills through manual training in our country in the late 19th and early 20th centuries, pre-engineering programs are now trying to also push the concept of students gaining career skills in engineering-related fields at an early age. In the *Project Lead the Way* model of pre-engineering courses, *Principles of Engineering* is a course where students can explore engineering as a career, understand what engineers actually do, and see how they use science and math every day effectively (Lewis, 2004). The *Engineering by Design (EbD)* course *Engineering Design*, the capstone course for the International Technology Education Association (ITEA) curriculum, incorporates many of the actual experiences that engineers encounter. Capstone *EbD* students are challenged to participate as members of engineering teams within a typical business organization, while work completed will be reflective of authentic engineering projects found in the designed world (ITEA, 2007). E/TE students should be held to high accountability, just as practicing engineers are. E/TE classrooms should be organized, civil areas of learning and work-based simulation; as true to life as the school and instructor can make it within the educational environment's limitations. Work-based simulations can entail presentations, group work, deadlines, etc. – all important concepts for any class, but in this case, tailored to an engineering environment. Students who can successfully experience this type of work-based simulation can gain many positive experiences that can propel them into positive college engineering experiences. These college experiences are positive because in many cases, the students will have seen some of the curriculum before, only introduced and simplified for ease of understanding.

Incorporating Both Engineering/Technology Education Theory and Practice

In the *Standards for Technology Literacy* (ITEA, 2000/2002), the national standards created by the ITEA from 1994-2004, the content for technological literacy closely aligns with the content used by engineers. For example, in the teaching of Standard 9, *Engineering Design*, and Standard 11, *Apply Design Processes*, students can actually experience the procedures real engineers use to design products and systems. The *Project Lead the Way* curriculum is based upon the national standards for Science, Math, English and Technology Education (PLTW, 2006). The writers of these standards and curriculum understood the important role the pre-engineering education would have on the future of technology education. Teaching pre-engineering concepts and giving students real-world engineering situations to learn from are learning experiences many experienced technology educators may not have used in their classrooms. By solely putting the teaching of their students' technology literacy in the foreground, while placing the teaching of specific career skills in the background, some teachers may have put some students at a disadvantage when they began their university training.

Engineering/Technology Educators must present students with both theory and practice. On any given day, however, either may become more important than the other. When students are lacking in a particular concept area in terms of knowing something "technologically," it is important for the instructor to perhaps stop the engineering lesson and go back to teach some technology concept that multiple students didn't pick up on in the past, or set aside extra time for these students to remediate in that area. Many other days, instructors are covering engineering concepts, presenting experiences and case studies, and letting students involve themselves in projects that mimic (with limitations) what many engineers go through in their daily routines. This is the reason why many of the students in pre-engineering courses took them as electives – to see if a future career in engineering is right for them. They may only find these specific career skills in the E/TE classroom, and it is the instructor's job to try to the best of their ability to satisfy that curiosity.

Conclusion

A balance between when to teach theory and when to let students experience practice needs to be attained in the E/TE classroom. This balance can be achieved through vigilance and observation by the E/TE instructor. The instructor's main job should be to ensure technological literacy for all in the classroom. The students need to become technologically literate for today and tomorrow's world, no matter what career pathway they choose to take. Helping develop career skills through pre-engineering practice should not automatically be the first priority until technology literacy theories are mastered first. Getting to know one's students closely, understanding their strong points and limitations, and sensing their levels of interest can help the E/TE educator formulate a balance between when to put career skills into practice in the classroom, and when to perhaps scale back and work on the theories of teaching technology literacy for the future success of all students in the Engineering/Technology Education classroom.

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