Design and Assessment of an "Engineering" Course for Non-Majors

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Abstract

As a profession, engineering is not well understood by the general public. Engineers are perceived as "geeks" who love math and who have few interests outside of technical work. In short, the engineering profession has an image problem. In order to counteract this negative stereotyping, an engineering course for non-majors was developed and offered at Michigan Tech. This course has two primary audiences: pre-service math and science teachers and business majors. The course is titled "Engineering for Non-Believers" and stresses hands-on, project-based work. This paper will describe the course content and will present assessment results from the first offering of the course.

Index Terms - General Education, Hands-on Learning, K-12 Teaching

Rationale

Engineering involves the application of math and science in the solution of problems that face our society. Although engineers have been responsible for many of the great technological advances in our society (the space program, microcomputers, the transportation system, etc.), engineers have an "image" problem. Most people, including pre-college teachers, simply do not understand what engineers do. When it comes to positively influencing the life and/or career choices of a young person, teachers are in an unparalleled position to offer encouragement for the pursuit of an engineering degree. However, if teachers do not themselves understand the engineering profession, they are not likely to offer this type of encouragement. In May of 2000, Michigan Tech received a grant from the National Science Foundation titled "Engineering Applications in Pre-College Education." As a part of this grant, we proposed to offer a course that featured engineering applications of math and science for teacher preparation candidates. A major goal in offering this course was to give teaching candidates ideas and activities that they could, in turn, use in their classrooms.

At Michigan Tech, teacher preparation candidates do not obtain a major in Education, rather they earn a major and a minor in subject areas and take additional coursework in pedagogy to qualify for teacher certification. The structure of our teacher preparation program means that the candidates' schedules are often overcrowded with required courses, leaving little room for electives. However, each Michigan Tech student is required to take five elective General Education courses for graduation. Based on these boundary conditions, the decision was made to develop a General Education course on engineering applications. Although the aim of this course is for future teachers, offering it as an elective General Education course required broadening its focus to appeal to the entire campus community. The course is not allowed as a General Education elective for engineering students.

One source of students for the course in addition to teacher preparation candidates exists in our School of Business. Students who enroll in Business are required to take 6-credits (two courses) in "technology" electives. The technology electives can be in courses offered through the School of Technology or the College of Engineering. Before the development of this General Education course, business students have been hampered in their ability to take engineering courses due to a lack of prerequesites.

The title of our course is "Engineering for Non-Believers." It is a three-credit course that meets for two sessions of two hours each per week. The focus is on hands-on activities that demonstrate engineering practice. Students in the course complete a semester project; the project has been tailored to meet the needs of the two primary audiences in the course, teacher preparation candidates and business majors.

Background

The American Society for Engineering Education (ASEE) has called for engineering colleges to partner with elementary and secondary schools, the broader university, and the local community and government in its *Green Report: Engineering Education for a Changing World*.[1] One activity they recommend is for engineering colleges to reach out and connect to K-12 schools in their communities to ensure that students, particularly in middle school and high school, have the information they need to make informed decisions about an engineering career. They see this early outreach as crucial as engineering differs from most other professions in that students have to make a decision early in their secondary school preparation in order to maintain an option for engineering studies. ASEE suggests several joint activities in which colleges of engineering and local school districts might engage: developing summer and evening courses for teachers on-campus or at a local corporate facility; forming a speakers bureau;

providing mentors; and offering laboratory classes taught by faculty, engineering students and corporate engineers. Regardless of final outcomes, activities should focus on the needs articulated by K-12 school administrators and teachers, not just those activities that engineering educators and their corporate colleagues are presently prepared to provide.

ASEE also recommends that engineers work with colleagues across the university to promote technological literacy for all students by accepting responsibility for providing technical programs to liberal arts students. These activities will ensure that all students better understand the implications of technology for society. Activities identified by ASEE include developing and teaching courses that provide laboratory or design experience for non-engineers, examining the history of science and technology, or discussing the interaction of technology and society. [1]

The National Science Foundation (NSF) has also charged engineering colleges with assuming responsibility for promoting technological literacy throughout the university and to provide opportunities for non-engineers to study engineering topics. Technological literacy is imperative in our technological society, and students should understand not only the "nuts and bolts" of technology, but also its evolution and cultural, political, legal, environmental, and economic impacts. NSF recommends including engineering-based curricula in medical, law, business, and K-12 education curricula, and offering "engineering appreciation" courses for other non-majors. [2]

The engineering departments of several universities such as Carnegie Mellon University, the University of Pennsylvania, Lake Superior State University, the University of Denver and Princeton have risen to this charge and offer courses for non-majors which serve as minor or technology electives. [3][4] Two examples of such courses are described below. Another university, the University of Washington, offers a course to non-engineering students simply to educate future non-engineering employees in the aerospace industry. Due to its location in the Pacific Northwest where the aerospace industry is a major employer, the University of Washington offers *AA101:Air and Space Vehicles*, to both pre-engineering and non-engineering majors. Course objectives are that students should be able to explain to others how airplanes work, why the Space Shuttle can only attain low Earth orbit, why there are launch windows to Mars only every two years and more. This course is so popular that it is offered three quarters every year. [5].

Exploring Technology is a recently developed course offered for non-engineering majors at Lake Superior State University. The rationale for the course is based on the fact that most individuals use new technologies in some aspect of their daily lives. This means that familiarity with new technology is a necessity and no longer an "option." People working in STEM fields are able to remain current regarding changes in technology and specifically, engineers are usually directly involved in the creation of new technologies. However, the general public is often not well-informed about the proper application of new technologies nor the existence of alternatives to them. The general public also does not understand the processes involved in developing these technologies. The LSSU course was designed to alleviate the fears involved in using new technologies, instill confidence in students' abilities to adapt in an emerging highly technical society, and instill the desire to question a process or procedure. The LSSU course is team taught by six faculty and is open to both non-engineering and engineering majors with a prerequisite of high school algebra. The course is a four-credit-hour course, it meets for three one-hour lecture periods and has a weekly laboratory session. The focus of the first two weeks is an introduction to the various disciplines in engineering and technology and on developing basic computer literacy. Four weeks are then spent on each of the following areas: mechanical, electrical, and manufacturing engineering. The outcomes of the course are that student participants will have confidence in using computers and other modern equipment, have problem solving and communication skills, and understand the role of technology in society. [6]

Princeton University offers a seminar course, *From the Earth to the Moon*, to first-year undergraduate students. This course presents both the science and technology of space flight, from orbital mechanics, launch, and re-entry, to navigation and communication, and the societal impacts including the history, dreams, business and politics of space flight. This course fulfills a dual role of exposing non-engineering students to engineering technology and engineering students to societal impacts of technology. About half of the students that take the course plan to major in the humanities, but it is assumed all students taking the course have had calculus and/or physics in high school. [7]

William S. Hammack, Associate Professor of Chemical and Biomolecular Engineering at the

University of Illinois at Urbana – Champaign, goes beyond promoting technical literacy in the university. He focuses almost exclusively on explaining engineering and technology to the general public. His goal is to enhance "engineering awareness" and to add a human face to the engineering enterprise. He does this through several venues: (1) via commentaries on public radio, (2) by teaching an innovative course to students who are not majoring in science and engineering at the university, (3) through public speaking, and (4) through books and magazine articles. Every week for the last couple of years Hammack has produced an essay and radio show focusing on common articles found in everyday life. His talks (150+) have focused on things such as how engineering has changed the nature of housework and the origins of typewriters, potholes, and Velcro. These talks, lasting just two or three minutes, are distributed across the state by Illinois Public Radio and can be accessed from his webpage. His course, *The Hidden World of Engineering*, is taught every semester to a diverse mix of students majoring in commerce, architecture, photography, history, and graphic arts. This popular course gives students an appreciation for engineering and for how engineers think by letting students work in teams and actually do engineering. Professor Hammack's position is unique, there is none like it in any engineering college in the nation. He is the only engineering professor tenured for his outreach work. He received the Award for Distinguished Literary Contributions Furthering the Public Understanding of the Profession from the Institute of Electronics and Electrical Engineers in 2004. [8]

Although the universities mentioned above all offer courses for non-engineering majors, Michigan Tech appears to offer the only course designed with future K-12 educators in mind.

Course Topics

The topics in the course are of a general nature with a focus on fun, hands-on, interactive learning. Since the hands-on activities used in the course are intended to be used eventually at the high school level, they have to meet the criteria of being interesting, easy to administer in a high school setting, and use only inexpensive and easy to get materials. Topics are selected to avoid a great deal of math and complex science for two reasons: (1) the topics covered are intended to be used, in some form, in high school classes where the average student's math skills are well below those of college students, (2) many of the students who take Engineering for Non-Believers lack the math background to solve problems such as those found in traditional engineering courses such as Statics or Dynamics. The math used in the course is kept to algebra and some simple trigonometry. One topic that works well in the course is The Engineering Design Process. This topic is the main theme of the course around which other topics revolve. A typical engineering design process is presented near the begining of the course and is refered to often as other topics are studied. Table I outlines the weekly schedule of the course.

During the introduction to engineering sessions, students learn what distinguishes engineering from science. The history of engineering and its foundation in military applications is discussed. Along with the history

TABLE I
Engineering for Non-Believers Course Outline

Week	Topic
1	Introduction to Engineering-The History of the Profession, Engineering Disciplines
2	The Design Process & Mini-design project, Patents and Engineering
3	Spatial Visualization Skills-Isometric and Oblique Sketching
4	Spatial Visualization-Orthographic Sketching, Computer Aided Drafting
5	Introduction to Semester Design Project & Exam I
6	Design-Engineer-Construct project delivery simulation (DEC simulation)
7	Completion of DEC simulation
8	Forces-Harnessing Forces to do Work - Mouse Trap Cars, purposeful design
9	Forces-Bridge Applications, West Point Bridge Designer
10	Strength of Materials-Terminology and Testing
11	Electricity and the Simply Super Circuit Board
12	Electromagnetism and a Simple Motor & Exam II
13	Reverse Engineering / Mechanical Dissection
14	Engineering and the Environment
15	Student Design Project Presentations

of the profession, a discussion of how specific engineering disciplines (civil, mechanical, etc.) evolved is presented.

The cornerstone of the course is a semester design project which is completed in teams of two or three students. These projects are tailored to the needs of the diverse audience in the course. For example, teacher preparation candidates were assigned a project to develop a teaching unit using LEGO RCX bricks that could be used in K-12 classrooms. Student teams are expected to include drawings and written documentation of the design solution as their final product in the course. This is similar to projects in courses at the University of Colorado – Boulder and Rice University. [4]

After the introductory sessions, students are required to find articles in magazines and journals which show how engineering affects our society. Each student then presents their article to the class using electronic slides. The presentations focus on the engineering behind the technology and how the technology benefits and/or harms the public. These presentations are given once or twice per week throughout the semester.

The Design-Engineer-Costruct (DEC) activity simulates the engineering process for a construction project. This activity is based on one developed by Dr. Kris Mattila at Michigan Tech. The first day of this simulation, student teams act as the "owners" who must develop specifications for a device they would like to have built. The device will be built from LEGO bricks, pencils, and rubber bands and must interact with a golf ball in some way. For example, they could specify a structure that encloses a golf ball and suspends it from the table top. At the completion of this day, client teams have written a document describing their desired product. The following day, student teams exchange project descriptions and become "engineers." Using the written project description from another group, engineering teams develop a set of drawings and construction specifications that can be used to build a device that satisfies the owner's needs. The engineers must also prepare an estimate of the project cost, and a bid package that will be used to obtain bids to build the project. When creating the construction documentation, students are not allowed to build with LEGO bricks, but must develop drawings based on standard sizes. On the third day, students exchange papers once again and are now the "contractors" for the project. Contractors make their own cost estimate of the project based on the engineering documentation and then must procure the construction materials from the supplier (the instructor). To add realism into the activity, the material supplier (instructor) may "change the rules" by doing things like creating a shortage, and therefore an increased price, of certain materials. Contractors are sometimes surprised to find out that certain parts won't be available for several days because of a strike at the manufactuing plant, or that red blocks are sold in lots of five, and not three. Teams then watch as contractors build the structure from the engineer's drawings. Clients and engineers who are observing the construction are often surprised to see the final result as interpreted by the contractors. In a follow-up session, the importance of communication in the design/build sequence is discussed among participants.

Topics like the design process and engineering history give a "big picture" view of the world of engineering, but to give non-engineers a more complete look at what engineers do, this course spends time on some specific concepts that affect almost all engineers. One such concept is forces. In this course, forces are divided into those used to move things (motive forces) and those acting on static structures (static forces). Specifically, students examine the forces which act to make a vehicle move, and forces acting on a truss bridge. To study motive forces, students design and build a vehicle to accomplish a given task that is powered only by the spring in a standard mousetrap. Examples of the design task are to build a car to travel 15 feet in the shortest time, or to pull a weighted sled up an inclined plane. This activity works well in examining how varibles, such as the wheel/axle ratio, can be optomized to meet a specific need. When studying forces that act on truss bridges, students use West Point Bridge Designer (WPBD) software. WPBD was developed by faculty at the U.S. Military Academy at West Point and is available (at no cost) over the Internet (www.usma.edu). With this software, student teams design a truss bridge to span a given distance. Students define joints and members in the truss and then test the bridge by driving a virtual truck across it. As the truck moves across the span, the computer displays truss members changing colors to indicate stress levels, i.e., light blue indicates a low level of stress and dark blue indicates a high level of stress. The color also indicates whether the truss member is in tension or compression – blue for tension, red for compression. If the stress in a given member exceeds its capacity, the member fails and the bridge collapses. The goal is to design the least expensive bridge that carries that required load. This tool is a good way to introduce many engineering terms such as tension, compression, factor of safety, design load, live/dead load, etc. Once students are comfortable with the software and can build a bridge that doesn't fail under testing, the focus again turns to design optomization. Each truss member and configuration has a cost associated with it and students work to iteratively design the bridge while driving the cost down. The final task with this activity is to build a safe bridge at the lowest cost.

In addition to the interactive software developed at West Point, there is also a Teacher's Guide that is freely available to assist K-12 teachers in utilizing the software in the classroom. Using this Guide, students can build a truss bridge out of manila file folders. One chapter in the Teacher's Guide is devoted to stress, strain, and basic mechanics of materials concepts. [9] It also includes a procedure for testing file folder material (lightweight cardboard) is outlined. The tests simulate the kind of tension and compression testing done on real engineering materials, but with simple inexpensive materials. Students follow this procedure to test materials and gather data, then graph the results to quantify how the material behaves in both tension and compression. The goal of this activity is to have students understand what varibles, such as specimen length, cross section and type of loading, affect how a test specimen will fail. Students also get experience with designing an engineering experiment, gathering data, and interpreting experimental results.

Another type of force that engineers deal with on a regular basis is the electromagnetic force. This type of force, is more abstract, so the theory behind it is not discussed in much detail. To introduce this topic, students are led in a discussion about the prevalence of electrictricity, especially lighting and electric motors, in our society. The goal of this part of the course is to further the students' understanding of how electricity is "made" from mechanical energy, and how it is then often converted back into mechanical energy by electric motors. To begin, there is a brief unit on what electricity is (flowing electrical charges) and the nature of an electric current. Then a simple circuit is diagramed and explained. In the following session, students build a simple circuit board out of foam board, brass fasteners, paper clips, and Christmas tree lights. Through this DC circuit they are able to observe the differences between parallel and series circuits and learn about why we need fuses (or circuit breakers) to protect circuits. Students can observe how a fuse works with this circuit by using strands of steel wool as a fuse. Once the basics of current electricity are covered, the discussion is directed toward how we make use of electricity in our society. This leads to the importance electromagnetism in both creating electricity from generators, and converting electricity to mechanical energy with motors. An activity is again used to help students "see" how these things are done. In the activity, students create a simple motor from a battery, a magnet, and a coil of wire. Although making the motor and seeing it work are both fun and instructive, it is not intended that students obtain a thorough understanding of electromagnetics through this project. This discussion leads nicely to the closing topics for the course, which deal with how engineering and society mix.

Many societies rely on the use of hydropower to produce electricity, and hydropower projects are great examples of the relationship between technology and society. Several of these projects are researched by the students using the Internet. Then students are assigned a short reading about the Three Gorges Dam in China. [10] The Three Gorges Dam will be the largest hydropower station and dam in the world, with a 1.2 mile stretch of concrete and a 370 mile-long reservoir, 525 feet deep. This project will cost more than virtually any other single construction project in history (over $27-billion) and is surrounded by many controversial environmental and social issues. After reading the article and doing more Internet research, class discussion centers around the ethical and social responsibilities of engineers and how these sometimes compete with an engineering project that is constructed to serve society. In particular, the engineer's responsibility in protecting the environment is discussed at length.

Reverse engnieering is a topic that these students seem to enjoy and learn a lot from. In this activity, students chose a simple mechanical device and take it apart. The parts are then assembled in an "exploded view" fashion on a display board, each part is labeled and its function is described on a separate sheet. This activity also requires the students to consider how well the design fits with the product's function. Students are asked to comment on how they could change the design to perform better, or to perform a slightly different function.

As stated earlier, the cornerstone assignment for this course is a semester long, multi-part, design project. The project is introduced early in the course after discussing the design process. For this course the process is presented as a sequence of steps which typify the development a new product. The process begins by identifying a problem or need, and then moves through a solution generating and selection phase. Once a solution is selected, it needs to be designed and documented so that it can be built. Students work in teams to identify a "problem or need", and then throughout the semester turn in deliverables to document their design work. Students are required to use both written and graphical communication, such as memos, sketches, and CAD drawings for these deliverables. In the inaugural semester of the course, student projects varied from designing a longer lasting street hockey stick (with ball bearings on its contact surface); to developing plans for covered walkways to keep people warm as they traverse our campus during the cold winter months. These projects are presented to the class at the end of the course as if each design group were seeking funding to continue the project.

Course Evaluation

A total of fourteen students enrolled in the course in its initial offering and a pre-survey was administered on the first day. There were five short-answer questions on the survey. A post-survey containing identical or similar questions was given at the completion of the course. Eleven students completed both the pre- and post-surveys. Table II lists the questions and some representative responses from the pre-survey.

As the data from the pre-survey suggests, most students who enrolled in the course had a general understanding of the engineering profession. This could stem from the fact that as a technological university, Michigan Tech has more than 60% of its students enrolled in engineering programs. Therefore, most non-engineering students interact with engineering students on a daily basis and many students not currently enrolled in engineering started out in one of the engineering programs. Table

TABLE II
Pre-survey and Student Responses

Question	Responses
What is Engineering?	designing components that make things work
	designing roads, buildings, bridges, so they can be safely and efficiently built
	process of designing and developing products for industrial and commercial applications
	finding and providing solutions to physical problems
	building and designing things with focus on problem solving
	using thoughts, formulas, and other ideas to create and improve things
	finding the best way to do things
	study of how and why things work - requires great knowledge in calculus and physics
	science of how things work - deals with a planning structure to design parts
Write five words (or short phrases) which you feel characterize engineering as a job.	science and math (9)
	design (7)
	creativity (5)
	creation (5) - building, manufacturing, making things, etc.
	problem-solving (3)
	challenging (3) - hard, difficult
	big money (2)
Describe why you took this course.	to learn what engineers do, or more about engineering
	to improve resume by having an "Engineering" course on transcript
	needed gen-ed credits
Describe what you expect to learn from this course.	how to integrate engineering concepts into my classroom if I become a teacher
	about engineering jobs
	about basic concepts in engineering
	how to design things
	how engineering affects our society
How might this learning help you in the future?	to help in getting, or in doing, a job (career)
	to be more literate in technical settings
	having a broader education will be generally beneficial
	I may want to pursue a degree and career in engineering
	to better understand how things work

TABLE III
Post-survey and Student Responses

Question	Responses
What is Engineering?	applying math, science and technology principles to solve problems
	identifying a problem or need and developing a feasible solution using math and science principles
	using processes to develop (design) a product or system
	combining knowledge of math, science and economics to solve technical problems that confront society
	solving technical problems in society while keeping in consideration the interest of the public
	using scientific and technological knowledge to design or construct something
Write five words (or short phrases) which you feel characterize engineering as a job.	creative (7)
	design (7)
	challenging/demanding (4)
	innovative (4)
	technical (4)
	math-intensive (3)
	teamwork (3)
Describe why you took this course.	seemed interesting
	to learn more about engineering and what engineers do
	to learn a few engineering basics
	needed gen-ed credits
Describe a major concept (or concepts) learned from this course.	iterative design process
	people from all backgrounds are needed to create the best outcome
	need three things for engineering projects to be implemented: technology, social need, funding
	how owners, engineers and contractors work together to get a job done
	how generators and motors are different
	forces/strength of materials/electricity/manufacturing/construction
How might this learning help you in the future?	may be able to apply this knowledge to everyday life
	engineering problem solving process can be used in the business world
	in construction - have a better understanding of how strength is affected by length and shape
	communicating or working with engineers
	made me think differently about things and consider more ideas
	everyone should have knowledge of engineering because it is used everywhere
	an engineering class on my transcript will be useful when looking for a job

III lists the questions and some representative responses from the post-survey.

The post-survey data show that students had a clear understanding that engineering involves solving problems using math, science and technology. For the question "What is engineering?", 73% responded to that effect. Students also appeared to gain an appreciation of the societal influence on engineering and the impact engineering makes on society. Almost all students gave positive examples of how the things they learned in the course could help them in the future.

An additional assessment form was completed by the students at the end of the semester. This evaluation form consisted of several questions regarding student perceptions before and after the course. Although the "Before" data gathered from this instrument is not ideal, the assessment seems to show some shifts in student attitude. A total of 10 students completed this questionnaire which asked them to rank their confidence and interest levels on a 0-5 scale, with 0 indicating a low and 5 indicating a high confidence/interest level. Tables IV & V present data from selected questions on the questionnaire as well as an indication of the statistical significance of gain in the scores

The data in tables IV and V shows student confidence levels in understanding and performing basic engineering tasks improved significantly through participation in the course. Their increased interest in taking more engineering courses may be directly correlated to this increase in confidence. Interest in engineering and science and teaching these principles in a K-12 setting rose. Students showed significant improvements in their confidence in teaching engineering concepts in a K-12 setting even though the students that completed the questionnaire were not pre-service teachers. Students were also asked

TABLE IV
Confidence Before/After Mean Responses

Confidence in your ability to . . .	Before	After	Gain	Level of Significance of Gain
Understand key concepts of engineering	2.0	4.1	2.1	P<0.0005
Solve engineering problems	1.9	3.6	1.7	P<0.0005
Use engineering principles in “real life”	2.3	4.0	1.7	P<0.0005
Perform lab experiments	2.3	3.8	1.5	P<0.005
Visualize key concepts of engineering	1.9	4.1	2.2	P<0.0005
Apply your knowledge of engineering to teaching	1.5	3.4	1.9	P<0.0005
Understand other areas of science	2.8	3.6	0.8	P<0.025
Succeed in another engineering course	1.8	3.6	1.8	P<0.005
Teach engineering concepts to K-12 students	1.7	3.5	1.8	P<0.0005
Create hands-on teaching units and labs	1.7	3.4	1.7	P<0.0005
Average confidence	2.1	3.8	1.7	P<0.0005

TABLE V
Interest Before/After Mean Responses

Interest in . . .	Before	After	Gain	Level of Significance of Gain
Learning about engineering in general	2.3	3.6	1.3	P<0.025
Science in general	1.8	2.5	0.7	P<0.2
Working with others to learn science	1.6	2.2	0.6	P<0.2
Teaching engineering principles in a K-12 setting	1.0	2.0	1.0	P<0.025
Teaching science in a K-12 setting	1.2	1.7	0.5	P<0.3
Taking more engineering courses	0.8	2.3	1.5	P<0.0005
Average interest	1.3	2.2	0.9	P<0.05

several questions related to whether they were more interested in pursuing an engineering or science degree or teacher certification after taking the course. Although their interest in these did increase after taking the course, it did not appear their interest was high enough to cause them to change their major. This is likely due to the fact that the majority of the students were in their third and fourth year of study and had already declared a major.

Several questions on the questionnaire merely asked student opinion about the course and did not ask them to rate items before and after. These questions were also rated on a 0-5 scale, with 0 indicating Strongly Disagree and 5 indicating Strongly Agree. Table VI includes means for selected questions from this portion of the questionnaire.

From the data presented in Table V, it is clear that most students thought the course was a worthwhile and enjoyable experience. Overall, student response to the course was extremely positive as indicated by a mean rating of 4.6 on a 5-point scale regarding whether they would recommend the course to a friend.

Conclusions

A course designed to teach non-engineers about engineering was successfully developed and assessed at Michigan Technological University. A major goal in offering this course was to give teaching candidates ideas and activities that they could use in their classrooms to teach engineering at the K-12 level. Thus, the course included several hands-on, interactive activities that serve as models for K-12 students. These activities, and the course in general, were interesting and useful to the college students according to the post-course surveys. Students reported significant gains in their understanding of engineering and their ability to use engineering principles in “real life”. As these students continue their careers both in and out of college, it is hoped that their understanding and interest in engineering will advance the cause of developing a technically literate society.

TABLE VI
Opinion of course Mean Responses

Question	Mean Response
The applications of engineering discussed in this course made certain concepts easier to understand	4.8
The applications of engineering discussed in this course made learning engineering interesting	4.6
The labs helped me understand important concepts in this course	4.4
This course made me realize the importance of engineering	4.4
This course complements other courses that I am taking as part of my degree requirements	3.2
This course should be required of every student in my program	3.1
I did NOT enjoy taking this course	0.3
I would recommend this course to a friend	4.6

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at Michigan Technological University. Boersma is an active member in the American Society of Civil Engineers. Her research interests include spatial visualization and engineering education. Boersma worked in the field of on-site wastewater treatment prior to teaching at Michigan Tech.

Douglas E. Oppliger

Mr. Oppliger is a professional engineer who is a lecturer in the Engineering Fundamentals department at Michigan Technological University. He is

active in working with students and teachers to get more engineering into K-12 education. His outreach includes advising a FIRST robotics team and assisting several local FIRST LEGO League teams. In 2004, Mr. Oppliger was awarded the Distinguished Faculty Award for Service largely because of this outreach work. He has presented papers on engineering education at several conferences including the International Conference on Engineering Education in Oslo Norway in 2001. Before coming to Michigan Tech, Mr. Oppliger worked as a project engineer in the marine construction industry, then as a secondary math and science teacher.