Introduction to Engineering at Walnut Hills High School: The Students' Perspective

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Abstract

Introduction to Engineering, a two-course sequence required of beginning engineering students at The Ohio State University (OSU), is being taught at Walnut Hills High School in Cincinnati, Ohio, during the 2001-02 school year. The course has been modified so that it is taught over an entire school year rather than two 10-week quarters. However, the content of the Walnut Hills course is very similar to what is taught at Ohio State. Walnut Hills students maintain a portfolio of all their work in the Introduction to Engineering (IE) course and may use this portfolio to support a request for college credit for IE if they decide to attend OSU and major in engineering.

Fifty-nine students who had completed pre-calculus chose to take the elective IE course at Walnut Hills. The course is team taught by a math teacher and a science teacher at Walnut Hills with support from faculty and staff of the OSU College of Engineering. The students are active participants in assessment of the pilot IE course. They provide information on their attitudes toward engineering, skills they have learned, and applications of those skills in other courses. They are frequently asked to write about the concepts that were easiest to understand (and why), and those that were most difficult to learn (and offer suggestions for improving the instruction).

This paper has been prepared by a team of students selected from a group of volunteers. It describes the course from the students' perspective, focusing on the skills learned, activities that were perceived to be valuable and those that were not, changes in their attitudes toward engineering as a career, and suggestions for improving the course next year.

Introduction

A new course, Introduction to Engineering, was offered for the first time at Walnut Hills High School during the 2001-2002 school year. In another paper in these Proceedings[1], the Walnut Hills and Ohio State University faculty present a detailed description the Introduction to Engineering course, outline their goals for the course, and provide an assessment of the first year. This paper describes the course and its impact from a student's point of view.

The Introduction to Engineering course helped to give fifty-nine high school juniors and seniors a better appreciation and understanding of various engineering disciplines. With the help of Ohio State and General Electric, students had the opportunity to gain a head start on other college freshmen with an engineering major. The goal of the Introduction to Engineering course was to establish a strong foundation on which to build an engineering career.

Throughout this course, students study many of the basic engineering disciplines and fundamental concepts needed to form that foundation.

Basic Skills Learned

Two of the most important disciplines in this curriculum are not those learned through any math or science course. First is how to think with an engineering problem-solving mindset. Most students have never had engineering experience before. This was a new and often strange concept. Different activities were created to help the students understand this mindset in the early weeks of the course. For the very first lab, students were given limited materials (two sheets of newspaper, limited tape, two plastic cups) and were instructed to build a beam that would support a 200 gram load. This lab showed students that there are reasons why some designs work and some don't. This understanding helps the students to develop creative thinking and realize why testing an idea is so important to engineers. The second discipline is teamwork. Teamwork is a skill that needs to be mastered in order for students to do well in this course and in the world today. An engineering career calls for constant teamwork and compromise. No matter what a person does in life, they will have to deal with others at some point.

Ideas play a big part in the engineering field. Through different drawing techniques, students can bring their ideas to life. These techniques include isometric and multi-view drawing by hand and computer-aided design (CAD). Both enhance the students' thinking and designing skills. It is a very powerful tool for students to see an object in their head, and be able to create it. Ideas are pointless without the means to make them tangible.

Another engineering "tool" learned by the students is how to actually use the different tools themselves. Through both the Bike and Camera Labs many tools were used in order to obtain data:

- Dial Caliper
- Micrometer
- Deflection indicator
- Pocket Logger
- Oscilloscope
- Digital Multimeter

Once the data was gathered, students learned things such as lab report formats, important equations and Microsoft Excel. All three tools helped students take their experimental data and present it in a usable format.

Labwork

Engineering is an application of scientific knowledge to real world situations. To truly know what engineering is, students must have some sort of real life situations and projects to work on. That is where the labs come in. These labs are not simple, one-day labs that one would expect to do in a physics or chemistry class. They are a series of related labs, each series spanning about nine weeks, that allow the students to have a greater understanding of real-

world products. Then, the students work in teams to write up a lab report explaining why the lab was done, how the lab was done, the results, a discussion of those results, and, finally, conclusions about the lab. So far, we have studied a bicycle and a disposable camera.

The bicycle series of labs had two parts: actual labs, where characteristics of a bicycle were observed; and "long term projects," where each team designed a bicycle, its method of production, cost of production, and final price to the consumer. In the end, the students used the knowledge of stress and strain obtained from the actual labs, along with the ideas and methods commonly used by bicycle manufacturers, to design their own bicycle and develop a hypothetical company to produce it.

In the actual labs, three things were focused on: metal deflection, stress and strain, and use of common engineering equipment. The students learned how to use common engineering measuring equipment, such as the dial caliper and micrometer. Secondly, the students measured and compared the increase of deflection as more weight was added to each of three beams, two solid, each made of a different metal, and one hollow box. The amount of deflection allowed the students to calculate the stress and strain of the bar. The knowledge gained from the deflection lab was extended to the idea of the bicycle's forks. The students recorded, in two separate labs, the stress and strain on the forks when riders are stationary, and when riders are riding through the campus.

The long term projects gave the students the opportunity to create, just as engineers do in real life. Each team was instructed to "start a company," complete with a name and logo, that produces an original bicycle design. At the end of the quarter, each team was required to make a professional presentation, using Microsoft Power Point, demonstrating their company's strategy, their bicycle's design, and a breakdown of the costs.

The camera lab series consisted of five separate labs. Each lab focused on a different part of the camera. Camera Lab 1 was mainly preparation and introduction for the rest of the labs. It was just each student taking pictures of a bicycle wheel moving at a certain linear speed with and without the flash, and of an array of subtense bars.

Camera Lab 2 consisted of the students measuring the blur angle of the bicycle wheel spokes on the developed pictures and, from it, using the known speed of the bicycle, calculating the shutter speed of the disposable camera. Those results were then compared to the shutter speed of the camera, as measured with an oscilloscope. Also, the length of the flash was measured and incorporated into the lab.

Camera Lab 3 gave the students a brief lesson in optics and how optics plays a part in the function of a camera. Students learned about focal length, depth of field, the circle of confusion, and many other concepts. In it, students measured the width of the subtense bars, and, using Excel, calculated the most likely focal length. Using this, the students experimented with different possible values for closest and furthest possible focusing distance to try to get values for aperture diameter and focal plane length close to those that they measured with a dial caliper.

Camera Lab 4 gave the students a look at the electrical part of the camera. In this lab, students used a stopwatch, a Digital Multimeter (voltmeter), and an oscilloscope to measure the amount of voltage the capacitor must have stored to produce a flash. This was done two ways. First, the camera was connected to an oscilloscope that measured the voltage of the capacitor and the voltage of the light that turns on when the flash is ready. The time at which the light turned on was recorded as well as the voltage at that time. The second method was simply students recording, with the stopwatch, the time it took to charge the capacitor and, with the voltmeter, the voltage when the light turned on.

Camera Lab 5 focused on the manufacturing process of the camera. Students went to OSU for the day to utilize a laboratory on the OSU campus. The students participated in an activity that compared the fixed material location method of assembly to the sequential assembly line approach. The other part of the day was spent observing different types of manufacturing, including sheet metal blanking and injection molding.

Student Views on the Course

As Walnut Hills High School students participating in our IE course, the majority of us (57.2%) were very pleased about getting to experience this class. Some of us have thought about engineering as a college major, but we really didn't know what an engineer did. This course definitely has helped convince several of us to go into the field of engineering, not only as a major, but also as a career.

As any first-year course would, IE ran into its share of difficulties. Many were a result of lapses in communication between Ohio State and Walnut Hills High School faculty, or the inexperience of the teachers with teaching the course. Students suggested more training for the teachers, a better organization of the course that would allow for more time on labs and a better fit into Walnut Hills' school year, an increased involvement of practicing engineers, and a course structure that would delve into more areas of engineering.

We asked our classmates what they thought about the IE course. Fifty-six of the 59 students completed a written survey. First they were asked why they chose to take IE. The most frequent answers were because it sounded interesting (78.6%) and because they were curious about what in engineer does (59.0%). Student responses to several other questions are presented in Table 1.

Finally, students were asked to indicate how much they enjoyed the IE course on a scale of 1 to 10, with 10 being the highest. Figure 1 is a chart showing the number of students selecting each number from 1 to 10.

Conclusion

The engineering class at Walnut Hills High School is truly a special one. It gives students at this high school an idea about engineering before they go to college. Plus, it gives high school students a chance to experience real life things and design original devices, rather than doing labs that prove already existing theories and laws. But, like all projects, there were setbacks

and problems. The teachers teaching the IE class at Walnut Hills did not seem adequately prepared for some of the material. But, as previously stated, this is the first year this course was offered. There are things that definitely need to be improved, but there is quite a bit of potential in this class. Hopefully other high school students will receive the same opportunity Walnut Hills students have had.

Acknowledgements

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TABLE 1. Student responses to survey questions.

Question	Yes		Maybe		No	
	N	%	N	%	N	%
1. Did this course give you a better understanding of various engineering disciplines?	37	66.0	17	30.4	2	3.6
2. Did the first semester of the IE course provide you with an understanding of what an engineer does?	39	69.6	15	26.8	2	3.6
3. Do you ask questions when you don't understand?	39	69.6	10	17.9	7	12.5
4. Did this course improve your teamwork skills?	23	41.1	24	42.9	9	16.0
5. Do you feel that you have listened to all ideas and help given to you by your peers?	40	71.4	14	25.0	2	3.6
6. Do you feel that you have listened to all ideas and help given to you by your teachers?	40	71.4	12	21.4	4	7.2
7. Now that you have an idea of what engineers do (if you don't, leave blank), would you be interested in engineering as a major? (2 not answered)	38	67.9	5	8.9	11	19.6
8. Would you be interested in engineering as a career? (3 not answered)	35	62.5	7	12.5	11	19.6

N is number of students out of 56.

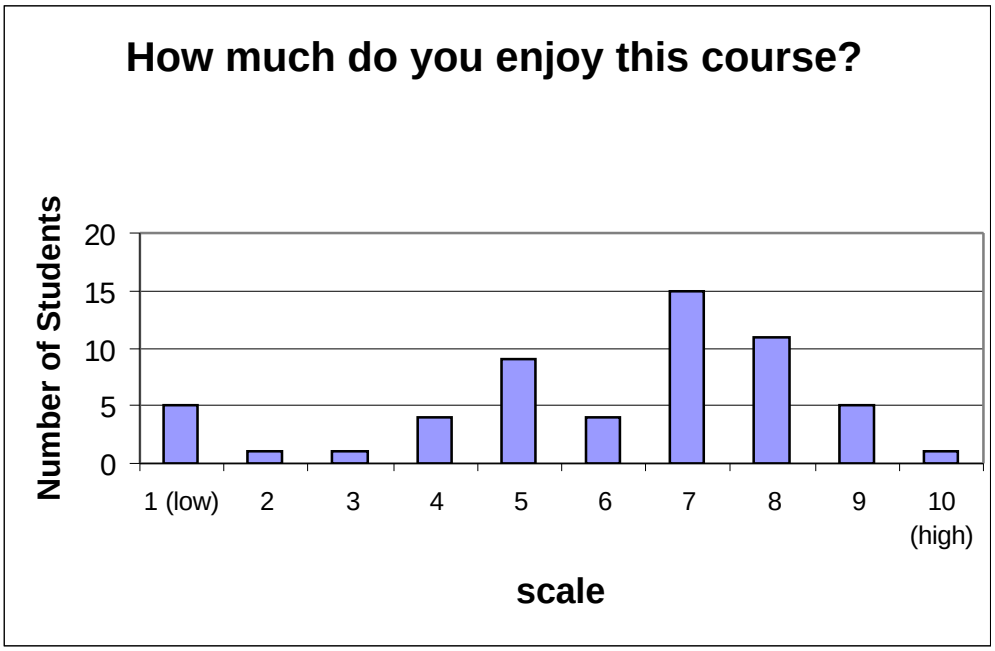

FIGURE 1. Student response when asked to indicate how much they enjoyed Introduction to Engineering on a scale of 1 to 10.

BIBLIOGRAPHIC INFORMATION

1. A.W. Fentiman et al, "Introduction to Engineering at Walnut Hills High School", 2002 American Society for Engineering Education Annual Conference, Session 3453.

BIOGRAPHICAL INFORMATION

BRANDY C. BISHOP is a senior at Walnut Hills High School. She plays soccer and does backstage work in productions held at her school. Ms. Bishop is enrolled in the Introduction to Engineering course and plans to major in Chemical Engineering at either Ohio State University or the University of Cincinnati.

ADRIAN J. BRUSH is a junior at Walnut Hills High School. He has volunteered for many projects, including at museums, for neighborhood beautification projects, and aiding in the learning of younger children. Mr. Brush also is actively involved in both the band and many math and science related groups and clubs at school. He is taking Introduction to Engineering, and plans to major in Engineering in college.

ALEXANDRA N. MENDLEIN is a senior at Walnut Hills High School. As a violinist with the Walnut Hills Senior Orchestra, she has played at Carnegie Hall and traveled to Spain, Mexico, and England. She is taking Introduction to Engineering and plans to major in Chemical or Materials Engineering at either Ohio State University or the University of Cincinnati in the fall.

MICHAEL MURRISON is currently a senior attending Walnut Hills High School. In addition to schoolwork and a part time job, Michael is the captain of the baseball team. He is taking the Introduction to Engineering course and will be majoring in Engineering in the fall of 2002 at The Ohio State University.