Developing a Multi-Faceted Survey of Engineering Course for Junior and Senior Level High School Students

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This paper describes a unique way to develop a survey course of the various types of engineering disciplines for high school students who are potentially interested in pursuing a career in the field of engineering. There are four major steps that were completed to begin development of the course. They are:

Step 1: Designating prerequisites and what courses could be taken concurrently.

Step 2: Selecting the types of engineering modules to be covered (i.e. civil, electrical) and the topics associated with each one of those modules.

Step 3: Deciding what types of engineering mathematics should be covered. Included with this step was the subsequent application of these mathematical techniques with meaningful examples.

Step 4: Selecting the course textbook/textbooks. This step was very challenging due to the fact that no single text book covered each of the topics of interest. Each one of these steps presented their own unique challenge. The effectiveness of the initial steps to create the course will be evaluated at various times during the course by using survey data.

Designating prerequisites:

Step one in the course development was designating prerequisites. This was a particularly important step because it had to coincide with step three which deals with engineering mathematics and their application. Because a substantial part of the study of all types of engineering deals with advanced mathematical techniques, it was decided that all students enrolling in this course must have already completed algebra two and chemistry. Furthermore it seemed appropriate that the students be concurrently enrolled in Advanced Placement (AP) calculus, pre-calculus and physics. A student who “successfully completed” algebra two or chemistry must have earned a grade of at least “B” in order to enroll in the Survey of Engineering Course. If this course had been structured as simply a survey of engineering course where specific engineering applications and their design had not been included, the course prerequisites/concurrents would not have had to have been this stringent. However, it was the intent of all involved that the course subject matter mimic a college course as closely as possible.

Engineering modules and topics:

Step two, which involves selecting the types of engineering subject matter (modules) to be included, is an ongoing process. It was decided that each year before the course is offered and the subsequent subject matter is finalized, that the students eligible to enroll in the class take a brief survey of what types of engineering are of interest to them. In that way, the course is specifically tailored to the group that is taking the course. With this in mind, because it is a Survey of Engineering Course, the most common types of engineering would always be highlighted. As the principal investigator, I have chosen the topics to be covered in detail every
year. They are Civil and Environmental Engineering, Mechanical Engineering, and Electrical Engineering. It was agreed upon that on a yearly basis the following specialties under each type of engineering would be covered.

**Civil Engineering:** basic truss analysis and hydraulics/hydrology
**Mechanical Engineering:** dynamics and thermodynamics
**Electrical Engineering:** basic circuit theory

The topics to be added based on the survey will be weighted by how many people are interested in that topic. For example, if four of the twenty people in the class are interested in being introduced to chemical engineering and only two of the twenty are interested in nuclear engineering, more time will be devoted to some chemical engineering topics because it was of interest to more people. Slightly varying the course content will be an important feature of this class because the material will be new and updated every year which will require the course instructor/instructors to maintain an “updated skill set” and keep abreast of the newest innovations and topics in the field. This particular format will also allow for significant study of special topics or unique projects in the field. Thus, current engineering designs and projects could be incorporated for use which is also essential for each student to have a grasp of some of the newest and most innovative design projects that are currently being completed. Furthermore, an introductory discussion of basic design concepts and procedures will be included. Because the course is broad-based and many modules must be discussed, the design process to be covered will be general but will contain all the necessary elements from project concept, selection and design of materials, design alternatives and material availability and cost.

**Mathematical techniques:**

Step three of the process dealt with what types of engineering mathematics should be covered and what meaningful examples should be used in the explanation of each topic on mathematics. It may seem that a detailed study of engineering requires much more proficiency in mathematics than is possible for high school students. However, the students enrolled in this class, based on the required prerequisites, will be well prepared for a general discussion of the modules and should be appropriately challenged by the additional math that this class provides. Part of this step also dealt with determining how much of the year long course should be devoted to this extensive study of math. Because the students who enroll in the class must be at least in pre-calculus and have an understanding that there is going to be some overlapping of topics involved in regards to the students actual math class and this course, the math topics discussed would have to be selected so that they are different or build on the students actual math class and are relevant to the topics/modules previously agreed upon. For example, the students will not only learn that the first derivative of a function is the velocity and the second derivative is the acceleration. Those concepts will be built upon by relating them to the study of mechanical engineering dynamics. There are many common in-class examples that could easily be shown to drive home the principles of velocity and acceleration such as simple projectile motion of particle (ping-pong ball) or an object moving down an inclined ramp. In this way the concepts of mathematics are directly related to the study of engineering which in turn enhances the students understanding of the subject. Initially, it was agreed upon that this kind of study of mathematics should be during the first part of the year in the course. The exact length of time spent on this area would be determined by the course instructor and would be based upon such factors as how quickly the members of the class were grasping the concepts and how many in-class examples
the instructor needed to use to explain the topic. The only stipulation in regards to time was that this portion of the course would be no longer than one semester.

Selection of textbooks:

Final selection of the textbooks that are appropriate for this course was a challenging process and is still ongoing. From the start of this entire undertaking all involved thought that for the course to be most effective it would have to have elements of technical engineering mathematics and the application of math and engineering design with meaningful examples. It also must have elements of various types of engineering topics from the various branches of engineering. However, it was thought necessary to keep the course as “fluid” and up to date with new engineering advances and design process while keeping all of the “tried and true” instruction practices of each branch of the field. As you could imagine, this made the task of selecting a textbook very difficult. As the principal investigator of the course, I and several other members of the course committee reviewed various texts. We wished to not only have books that were well done in terms of explaining math and engineering principals but they had to be written and worded in such a way that they spoke to the audience appropriately. Some of our initial selections were well done with explanations but missed the mark in addressing a high school student audience while others were too simplistic and not mathematical or engineering specific enough based on the level of learning or preparation that the students enrolled in the class already had. Based on all of this investigation and using input from the individuals who are going to be responsible for the course instruction, the committee members and I have focused on several textbooks that will be used in different durations and capacities. Below is a brief description of each text and what portion of the class that it will be used to teach. The final selection of text books for the first year in teaching this course was the decision of the author and the effectiveness of these texts will be assessed and subsequently modified if necessary after year one.

Technical Mathematics\(^1\) was selected as the text to be used to instruct the engineering math concepts. This book seems ideal because it reinforces many of the math concepts the students have in their math class and builds on many of them. Technical Mathematics\(^1\) is the text used at Youngstown State University in one of the foundation courses for the Engineering Technology program. This particular text will be paired with Thinking Like an Engineer: An Active Learning Approach\(^2\) because of the books detailed engineering applications and the manner in which the author describes how to solve engineering problems using all concepts of math in the Technical Mathematics\(^1\) text. The final text that is going to be used extensively is Engineering Design: An Introduction\(^3\) which is one of the primary teaching texts for programs that use the Project Lead the Way teaching materials. The extent to which each of these texts is used and the amount of supplemental texts and other materials used is still being decided and is the responsibility of the course instructor. Subsequent research and assessment needs to be done to determine if the texts listed here are adequate or need slightly amended which could be the topic of other papers.

Assessing the effectiveness of the course is going to be done primarily by survey method and will be done at various times throughout the entire academic year. As stated previously, a survey will be given to students prior to their course registration to determine the topics in the
field of engineering or engineering technology that they would like covered. A small portion of this survey will be dedicated to the students other expectations of the course and will be used to ascertain their overall understanding of the field. A sample initial survey is included as the last portion of this paper. Using this initial survey, the basic syllabus of the course can be completed and will be tailored to the interests of the class. This survey will also be crucial in assessing the students initial thoughts about the field of engineering. A similar survey will be given at the conclusion of the course to gauge if the material covered was relevant to their interests and if the material is something that they would consider studying at the college level. Also during the course, students will be required to complete surveys regarding each unit covered (i.e. civil engineering, mechanical engineering etc.) to determine if the topic was adequately explained and if the topic was what they envisioned. All of the survey data will then be analyzed to see if the course met the expectations of all involved and to ascertain what adjustments/revisions are necessary to improve the course. Any of these adjustments/revisions that are deemed necessary will be the topics of subsequent research and papers.

Sample Registration Survey: Engineering Course

Directions: Please answer each question below as they will be used to create a survey of engineering course that will be tailored specifically to this class.

1. In an effort to tailor this course to the students, please rank your level of interest in each of the following areas of engineering. An interest level of “10” would be most interested and a “1” being least interested.
   a. Mechanical (i.e. heating/cooling design, combustion engine design) _____
   b. Civil (i.e. trusses, beam and bridge design, roadway/pavement design) _____
   c. Environmental(i.e. water and wastewater treatment processes, storm water mgmt.) _____
   d. Chemical (i.e. design of chemical reactions/polymers) _____
   e. Electrical (i.e. computer design, circuit theory, digital electronics, microprocessors) _____
   f. Other _____

2. What specific topics under your two (2) favorite subjects of engineering above are of most interest to you?
3. Using mathematics is essential to being an engineer. Therefore, many engineering majors are mathematics minors in college. Please estimate your interest in a detailed study of mathematics in college.
   a. Very interested _____
   b. Somewhat interested _____
   c. Not interested _____

4. Many students interested in engineering are more interested in the applied aspects of the field (i.e. practical applications of the engineering principals rather than theoretical discussion). This area is called engineering technology and generally does not require an intense study of theoretical mathematics. Please estimate your interest in engineering technology.
   a. Very interested_____
   b. Somewhat interested____
   c. Not interested____

5. Would you prefer that the course instructor use textbook examples to explain the principals of math and engineering or are “hands-on” examples where the entire class can participate of more interest to you?

6. Do you get stage fright? Are you hesitant to speak in front of large groups of people? Communication, both written and verbal, is very important to the field of engineering. During the course of any engineering career, you will be required to communicate with people of all different trades, education levels and nationalities. Please rank your interest in giving a presentation to explain an engineering project in front of a large group of people. An interest level of “10” would be most interested and a “1” being least interested.
   a. Very interested _____
   b. Somewhat interested _____
   c. Not interested _____

References:
Today the introduction of the course “Professional English” or “English for specific purposes” into the academic curriculum for non-linguistic major students is considered more relevant than ever ago. This tendency can be explained by numerous job requirements that can be found and analyzed in various professional standards. The knowledge of professional English among necessary skills of different job functions is analyzed in this research. It’s worth mentioning that the knowledge of technical English is required for performing many tasks and activities one way or another in the sphere of engineering. SIMR is for high school juniors and seniors interested in hands-on research in immunology, stem cell, cancer, neuroscience, bioinformatics or cardiovascular medicine. This eight week program enables students to take part in research, attend introductory lectures and present their work at a poster session open to the Stanford community.

Stanford Institutes of Medicine Research Bioengineering Internship is an eight-week hands-on design and engineering experience for high school students from diverse backgrounds. Students are exposed to exciting and novel bioengineering research topics through lectures given by Stanford researchers. There is no cost to participate other than an application fee.

SMASH Academy on Stanford Campus. June 27 - August 1, 2020. Create school and student surveys online for free! Giving students, parents, and educators the opportunity to share their opinions will help keep your school on the road to success. Start collecting valuable feedback on course, school, teacher, or education surveys today.

School surveys help you discover if teachers feel they have the level of support they need in their work environment, and if faculty is satisfied with department leadership. Evaluate online learning programs. Online learning programs are becoming increasingly popular with college students, adults, and anyone wanting to learn more. Get student feedback in order to ensure your courses are achieving their learning goals. Are your lessons easy to access and understand? The beginning of higher engineering education in Bulgaria is established by the Law for Establishing a Higher Technical School in Sofia in 1941. Only two years later however because of the bombs flying over Sofia, the school was evacuated in Lovech, and the regular classes were discontinued. The learning process started again in 1945 when the university became a State Polytechnic.

Students receive first a baccalaureate degree (3 years of studies) followed by a master's degree (1–2 years of studies) according to the principles of the Bologna declaration, though traditionally. The engineering doctorate degree is the PhD (3 years of studies). The quality of Danish engineering expertise has long been much vaunted. Russian engineering education is of the highest quality and universities are competitive on the global scale (Aleksandrov et al., 2013). Most of the claims rely on experts’ evaluations, limited attempts to measure learning outcomes of students. Designed to test core math/science competencies that computing and engineering students learn in the first couple years of their programs. In the follow-up, we will be able to measure absolute learning gains in these core areas. Tests of major-specific knowledge. Students in elite universities have higher levels of academic skills than students in non-elite universities. But this is much more true for China than Russia (this is because of sorting into universities as attested by grade 1 student differences).