122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society

Paper ID #13634

ENCOURAGING STUDENTS TO SEE THE ROLE OF SERVICE COURSES IN THEIR MAJOR

Dr. Kenneth W. Van Treuren, Baylor University

Ken Van Treuren is an Associate Professor in the Department of Engineering at Baylor University. He received his B. S. in Aeronautical Engineering from the USAF Academy in Colorado Springs, Colorado and his M. S. in Engineering from Princeton University in Princeton, New Jersey. After serving as USAF pilot in KC-135 and KC-10 aircraft, he completed his DPhil in Engineering Sciences at the University of Oxford, United Kingdom and returned to the USAF Academy to teach heat transfer and propulsion systems. At Baylor University, he teaches courses in laboratory techniques, fluid mechanics, energy systems, and propulsion systems, as well as freshman engineering. Research interests include renewable energy to include small wind turbine aerodynamics and experimental convective heat transfer as applied to HVAC and gas turbine systems.

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Abstract

Many departments are involved with service courses which support both their programs and other programs across the campus. A service course is a required or elective course taught by other programs across the campus. These can be courses such as thermodynamics which could support all engineering disciplines or it could be computer or math courses which support majors outside their respective departments. It could also be liberal arts courses, such as English or History, which support engineering majors. In these service courses, often students do not see the relevance of the course to the major or sometimes engineering faculty downplay the importance of these courses to their major. This leads to confusion by the student concerning the content of the service course and its significance to their professional development. A goal of the paper is to describe the importance of service courses to an engineering curriculum and the role that engineering service courses can play in a liberal arts curriculum. Several examples are given as well as suggested opportunities for engineering departments to service their university through technical literacy courses. A specific example of a technical service course is a course taught by the author while on sabbatical at the USAF Academy. This course was an introductory course in aeronautics required by all students at the USAF Academy. The author's section had 23 students from majors as varied as English and History as well as Chemistry and Civil Engineering. In the syllabus 50 points (out of 1000) were allocated to instructor points to be used how the instructor viewed appropriate. For this section, the Cadets were asked to write a three page essay on how the subject of how aeronautics intersects with their chosen major. This posed a thought provoking reflection essay which was not expected in an introductory engineering class. Cadets were encouraged to talk with their advisor, other classmates, other Cadets in the major, and with the author. Several Cadets chose the latter and excellent discussions were had with the author outside of the classroom. As a result, the essays written were thoughtful and thought provoking. In a survey that was accomplished after the essays were graded and returned, many Cadets thought the essay experience was valuable and they appreciated the opportunity to reflect on the relevance of aeronautics to their major. They made connections between aeronautics and their major where previously they thought none existed. This had the effect of changing their attitude towards the course and the material, a positive outcome.

Introduction

With the implementation of EC2000 requirements for the assessment of engineering programs, the Criterion 3 Student Outcomes a-k have become an important part of any engineering major and are essential for accreditation.[1] Several of these criteria, listed below, present challenges to any program:

> The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program:
>
> (a) an ability to apply knowledge of mathematics, science, and engineering
> (b) an ability to design and conduct experiments, as well as to analyze and interpret data
> (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
> (d) an ability to function on multidisciplinary teams
> (e) an ability to identify, formulate, and solve engineering problems
> (f) an understanding of professional and ethical responsibility
> (g) an ability to communicate effectively
> (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
> (i) a recognition of the need for, and an ability to engage in life-long learning
> (j) a knowledge of contemporary issues
> (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

In particular, outcomes f, g, h, i and j are often supported with courses outside the engineering major. Thus, as part of a degree plan, students must take courses in other majors the purpose of which is to broaden the knowledge foundation for a particular course of study. These courses are often called service courses. A service course is a course offered by a department other than the students' major that is either required or an elective for the major. Likewise, service teaching refers to the practice of knowledge and expertise of one school or department to teach students in a course co-ordinated by another academic unit. Nankervis defines service teaching, according to the literature, as:

> "… the delivery of compulsory courses or elements of a program by a discipline with specific expertise to students from a different faculty, department or discipline. Models of service teaching can include tailored units of study for a group of students or broader courses for a variety of students in a mixed class." [2]

Liberal Education and Engineering

A liberal education refers to an education in the traditional arts and sciences but also includes a student's ability to think broadly and to tolerate ideas and behaviors of others through exposure to the arts, humanities and social sciences.[3] Thus, a liberal engineering education is defined as an engineering education that incorporates liberal studies requiring both depth and breadth in the arts, humanities, and social sciences. The question arises concerning the balance between an engineering curriculum and the liberal arts. Typical engineering curricula have approximately 20-26% of their courses dedicated to liberal or general education. These courses can include topics such as English, Technical Writing, Speech, History, Economics,

Philosophy/Religion, and language.[4] All of these courses help develop professional skills and intellectual capacity needed by an engineer. Through courses in the liberal arts engineers develop intellectual reasoning, good judgment, and communication. Some of this is development is accomplished by studying engineers and scientists, such as Newton and Einstein, who obviously used their abilities to enhance problem solving and creativity. Stouffer and Russell believe that a broad, holistic education has been shown to increase creativity and the ability to solve complex problems.[4] Students need to be reminded of these connections.

Engineering programs exist on the campuses of many liberal arts colleges. Lafayette College views engineering as one of the creative liberal arts.[5] Engineers use their talents and skills to design new things, much like an artist creates new art. Thus, Lafayette College believes engineering is a socio-technical process that is a part of the liberal arts because it, first, shares creative, innovative, and cultural elements with the other liberal arts disciplines and second, it is a mode of both inquiry and building understanding of the world. These fundamental concepts are typically taught to engineering students in an "Introduction to Engineering" course framework. Lee et al. list a number of college institutions whose engineering programs have a strong emphasis on liberal arts such as University Wisconsin-Madison, University of Michigan, University of Iowa, Smith College, Dartmouth, Leigh University, and the University of South Florida.[6] There is also an interest to start this emphasis on liberal arts and engineering as soon as the high school experience.

Often the perceptions that engineering and non-engineering majors have of each other contribute to the widening gap between engineering and liberal arts.[7] Faculty perpetuate the idea that liberal arts courses are necessary to graduate but are of little value to the major. Engineering students often do not give their best efforts in courses outside their major/department. This can lead to practicing engineers only focusing on their profession and neglecting the arts when it comes to life-long learning. More must be done to foster this appreciation for liberal arts in the university setting or before.

Liberal Arts Serving Engineering

When discussing service courses, people mostly think about how the English curriculum prepares engineers to communicate, both oral and written. At the University of Pittsburgh an English/Freshman Engineering Writing Program encourages the freshmen to learn about "science and engineering, the social context of the work that engineers and scientists do, and about themselves via intensive engineering-related writing assignments."[8] Thomas and Breitenberg advocate using "Nature's Designs" for inspiration.[9] The concept behind "Nature's Designs" is to encourage students who might be intimidated by the math and science to be comfortable observing the world around them. A more general education is also seen to be an important part of any program seeking to infuse engineers with an entrepreneurial mindset.[10] These courses can be courses in business education to include courses on economics and communication.

Engineering Serving Liberal Arts

Norton and Bahr outline a senior level course on materials for non-engineering students entitled "Materials: The Foundation of Society and Technology" as part of a broad program of study in

the Arts and Humanities, Social Science and Sciences.[11] The course gives historical highlights of materials and the impact these materials have had on society and technology. Items such as plastics, golf clubs, and hip implants are explored. Students who elect to take this course come from a wide range of majors such as education, marketing, architecture, and history. Some students are also engineering majors, seeking unique perspectives on materials not often discussed in a traditional materials courses. The course assessment indicated that some of the student in non-engineering majors did not see the connection of this course with their major. The conclusion was that the teaching faculty must help these students make the connection. Lab projects in these type courses, such as building a simple radio, simple electric motor, loudspeaker, a one-octave keyboard, and a CD-to-cassette adapter, are ways to demonstrate physical principles to non-technical majors.[12]

Technological Literacy

For an engineer, general education courses are typically thought of as courses outside the major. Approximately 90% of the courses taken by an English major are in their college as compared with less than 50% of the courses taken by an engineering major being in their college. In engineering, the composition of these remaining courses are approximately 22% in math and science and 28% in liberal arts.[13] Non-engineering majors must function in a technical world and be able make informed decisions in whatever profession they enter. Without an understanding of the basic principles underlying technology they will not be able to evaluate the consequences of their decisions. This knowledge is called technical literacy. These service courses for non-engineering majors can be similar to what is taught in most introductory engineering courses thus, alleviating the need for prerequisites.

Krupczak et al. identify the need for technological literacy in the general population. Efforts to achieve this in the university come in the form of service courses for non-technical majors such as "Science and Technology of Everyday Life," "Technology and the Human Built Environment," "Engineering in the Modern World," and "Technology Literacy: How Stuff Works."[14] An example of the impact of these types of courses is that pre-service elementary teachers lowered anxiety, increased perceived value, and increased motivation for science and technology.

Union College has directly addressed the perceived (or actual) gap between engineering and the liberal arts and have proposed a Converging Technology paradigm to address this gap.[15] They ask the two important questions about this discontinuity. "Can we continue to produce liberal arts graduates who have little understanding of the technical world in which they live? Can we afford to produce engineers with little understanding of implications of those technologies for the world?" They offer the following definition of technological literacy from the International Technology Education Association:

> "Technological literacy is the ability to use, manage, assess and understand technology. It involves knowledge, abilities and the application of both knowledge and abilities to real world situations. Citizens of all ages benefit from technological literacy, whether it is obtained through formal or informal educational environments." [15]

Technological literacy is being seen as a more critical area for all undergraduates including non-

STEM students.[16] Teaching technology literacy courses seem the logical way in which engineering departments can provide a service to the liberal arts.[16-24] Engineering 5, Science of High Technology is a course at San Jose State University that focuses on everyday technologies to teach scientific principles.[16] This is a course targeted at students in their first or second semester. Experience has helped the course become more effective in its purpose of exposing these students to the concepts of technology without "scaring" them with the math and science. Having the technology literacy course fill an open option in any engineering program presents challenges.[17] The professors teaching these courses would need to inform advisors as to the content and importance of this service course for any major. Targeting groups of student, such as those interested in homeland security or in combating terrorism, might be an option. An interesting concept to teaching technology is reported by Ollis.[18] In this course technological devices are discussed in the context of their use, content of technology, and then dissected as a contraption. This approach has proved very popular with students. Technology 21 is a course given at the University of Denver described as a course for leadership in the new millennium.[19] Students in this course are given training in energy, materials, gathering information, and how these topics relate to current global issues in hopes the they will ask the right questions and develop well informed answers. Identifying appropriate topics and models for use in such courses is also of interest.[23, 24]

Another solution for technological literacy at the university level is to provide physical science alternatives for non-engineering majors that introduce students to technology and the underlying scientific concepts.[25] As an example, Van Treuren and Gravagne at Baylor University saw the need for energy education for all majors and developed a course entitled "Energy and Society." It was targeted for students from the liberal arts majors who could take this course as their science elective.[26] Students in this course demonstrated an improvement in understanding of energy issues using a National Environmental Education Training Foundation survey instrument on energy literacy. While this course addressed the need for non-engineering majors to become technically literate, the contrast is Huen and VanderLeest who also see the need for involvement of a liberal and multidisciplinary education in engineering to solve the energy crisis.[27] This should be coupled with engineers being exposed to business concepts to develop an entrepreneurial mindset so that they can compete in the fast changing world of renewable energy.

The Intersection of Liberal Arts and Engineering

The solution to the balance of liberal arts and engineering service courses seems to involve both academic groups reaching out to each other. Many efforts are occurring across the country that are moving in this direction. Union College wanted to integrate engineering and liberal arts and piloted a program of guest lectures (engineering professors guest teaching in liberal arts classes and vice versa), modules and paired courses.[28] The College of St. Catherine, a Catholic woman's institution, desired to put some "engineering" into courses in education, health sciences, business and social work while preparing these women to pursue their engineering degrees with partner institutions.[29] Many events in the Mechanical Engineering Department of Michigan State University seek to promote liberal arts activities such as poetry and novel production with a positive effect of showing the intersection of art and engineering.[30]

Tang, working in the Department of Science and Technology Studies at Rensselaer Polytechnic

Institute, highlights this institution's efforts to integrate liberal arts and engineering as well as those at Harvey Mudd College and Smith College.[31] Of particular interest are the student perceptions at the institutions studied. Students see the value of learning communications skills, as an example, but perceive math and science skills are more important. Even with this emphasis at these schools, students see things only in the context of engineering. They are not aware of the broad social, political, and economic contexts of what they do as engineers. The conclusion is that faculty need to be more intentional in their classes and use pedagogy that helps students learn how to view what they do in the context of the service courses outside their majors.

One way to promote engineering and liberal arts is to use projects with an innovative and entrepreneurial emphasis.[32] Students are challenged by big questions that are open ended and that allows them to pursue creative solutions, typically in capstone projects. This helps students to see their engineering education in the global context.

Another way to integrate engineering and liberal arts is to develop minors such as "Technology Management and Policy" that is available at the University of Virginia.[33] As an interdisciplinary minor, it is open to all undergraduates. This program helped engineering students find relevant liberal arts courses that are a vital component of a professional study. If these courses are important for a minor, then some of these courses may be relevant to serve other engineers as well.

Special courses with an "engineering" emphasis which occur early in a student's academic career can actually show the value of engineering to students that previously were only considering a liberal arts major.[34] More specifically, a course at Elon University in the freshman year uses an interdisciplinary team experience of building a remotely operated vehicle for ocean going tasks. Experience shows this is a transformational experience when there is a tangible final product.

Engineering Service Courses for Engineers

Engineering departments are often called on to provide service courses to other engineering disciplines. Examples would be an electrical department providing a basic circuits course or a mechanical department providing a statics or dynamics course. Another area is that of teaching thermodynamics to non-mechanical majors. While these courses are designed to satisfy the major, often not much thought is given to those who take the course and are outside the major. Some institutions, such as Western Kentucky University, have created special courses like thermodynamics which more adequately address the needs of the non-majors.[35] These are created with the input from the serviced departments.

Capstone design experiences are service courses to engineering majors that provide an interdisciplinary environment and by necessity cause students to use many of the intangible skills learned throughout the academic program.[36] These experiences can be enhanced by including non-engineering majors as part of the design teams. An example occurred one year at the author's institution where a traditional art major was included on a senior design team. The resultant design changed from a functional, box-like design to one that was more aesthetically pleasing. Engineering students were not practiced enough to look at the project as an expression

of art. While a service course is usually the responsibility of one department, Fisher et al. suggests that close cooperation with the serviced departments is necessary, even to the extent that faculty outside the department might participate in the teaching. It is suggested that department chairs and senior faculty members take turns teaching these courses to elevate their importance and keep service course issues visible.

Teaching Liberal Arts Students at Military Academies

While there are many thoughts and ideas about what to teach as service courses, the challenge for engineering professors is what to teach once the students are in the service courses. Nowhere is this more evident than at the U. S. military academies. At these schools, engineering courses are required of all majors as these courses are considered essential to the military officer.[37-39] At the USAF Academy it is possible to graduate with a B. S. degree in English and History as all students graduate with a B. S. degree due to the technical content of the required core courses taken. The challenge is then teaching a required technical course when those in the course are not fully committed to engineering.[37] Butler and Wilson suggest some practical ways to make these service courses more successful.[38] The level at which the course is being taught seems to be important. A service course occurring later in the curriculum often means a more mature, prepared student which results in a more successful course. Material in the course must make sense and be logically presented with a unifying theme. Topics that are not relevant to the non-engineering student must be removed from the course. The text of the course needs to be readable on the level needed for the non-engineering students. Also, the course must have design projects or labs to help illustrate key principles. If the elements of the course work closely together then the goals will be achieved and students will obtain the maximum benefit.

Teaching Fundamentals of Aeronautics

During the academic year 2012-2013 the author had the privilege to serve as a Distinguished Visiting Professor at the USAF Academy. One of his responsibilities was to teach the required core Fundamentals of Aeronautics course, a course taken by all Cadets, typically in their Junior or Senior year. This course served aeronautical engineering majors, other technical majors, as well as liberal arts students. Therefore, this course fell into the categories of Engineering serving Liberal Arts and Engineering Service Courses for Engineers. On any given semester, there are several hundred Cadets taking the course. It was a 40 lesson course with 50 minute periods. The particular section that was being taught by the author had 23 students. Part of the course grading structure gave the professor of record 50 points out of 1000 points to use as Instructor Points (IP) any way the professor desired. Fifty points is not very significant in the course however it was enough points to keep the Cadets engaged. The course was mainly lecture with a lab and an Unmanned Aerial System design project. The version of the course taught by the author was offered to non-majors. Another version of the course was taken by Aeronautical Engineering Majors. As a result, there was a random mix of non-aeronautical engineering majors in the class to include science, math and other engineering disciplines as well as the liberal arts. With such a mix of majors having different levels of abilities and preparations, the challenge was to generate interest in the course. These students were on track to graduate and eventually would be part of the United States Air Force. The importance of knowing about how airplanes fly would seem a topic that would generate much enthusiasm.

This was not necessarily the case. The Instructor Points provided the basis for an assignment proposed to help students to see the value of Fundamentals of Aeronautics to their chosen major.

Assignment – Reflective Essay

While considering the dilemma of trying to connect Cadets with the course topic, aeronautics, it was thought a reflective essay might be one solution. Most engineering professors do not use reflective essays as a rule for several reasons. First, it adds quite a large grading workload which takes time. Second, many professors do not feel comfortable with their own writing ability and feel inadequate to grade grammar. Lastly, this is a very subjective grading exercise which requires some experience to distinguish what is an excellent, average, or fair paper. The goal of the reflective essay was to encourage Cadets to see the intersection of aeronautics and their major. It was to be due just before the Thanksgiving break to allow the professor a block of time for grading. The following were the instructions given to the Cadets for this exercise (AFSC – Air Force Specialty Code):

> ASSIGNMENT: For this assignment you will write an essay discussing the intersection of your academic major and the subject of aeronautics and airplanes in general. Relate this to the mission of the U. S. Air Force. How do you see the knowledge that you are learning in this course relating to your academic major, or more generally, the AFSC that you will be entering, especially if the AFSC is in the subject of your academic major. I know some of you will be going to pilot training. Obviously AE315 will pay a benefit to your AFSC. I would like to see your perception to the relevance of this topic, Fundamentals of Aeronautics, to the academic major that you are pursuing. Think "big picture." Examples might be fuels and the combustion process for chemistry majors. Systems engineering might look at the acquisition process of the F-35 and why this aircraft is so expensive. Management majors might look at how the Air Force manages new aircraft (mx, life cycle costs, etc.). Electrical engineers might look at aircraft control systems. These are just suggestions to help stimulate your thought process.
>
> The other suggestion is to talk with your advisor, with an AE315 instructor, or other cadets to obtain a topic upon which to write. PLEASE E-MAIL ME YOUR TOPIC WITH A SHORT SENTENCE EXPLANATION OF WHAT YOU ARE GOING TO WRITE ABOUT. Do this sooner than later. The actual essay is to be done individually. Use references as appropriate.
>
> DELIVERABLE: A two or three page essay on the topic of the intersection of your academic major with aeronautics. Write in the format of your choice. No cover page. Single or double space, your choice. Use references as appropriate.
>
> DUE: M33 15 Nov at the beginning of class
>
> GRADING: The essay will be evaluated on both subject content (85%) and writing ability/format (15%)

Essay Results

The students responded well to the exercise. The open ended format and instructions were at first a little frustrating. Several of the students came to visit the author and started great conversations about the assignment and what aeronautics is all about. The conclusion of the discussions gave each Cadet direction and several ideas on what to include in the essay. All students wrote 2-3 pages as instructed using double spacing. Three students used single spacing. The final grades ranged between 40 and 50 points out of 50 with 74% receiving a perfect score for having satisfied the intent of the assignment and for writing well. Again, this assignment was mostly to encourage the students to look at aeronautics differently. These excellent results led to the conclusion that most of the students took the assignment seriously. Cadets who were atmospheric science majors wrote about winds and their effects on aircraft as well the effect of atmospheric icing on the aerodynamics of the wings. An astronautical engineering major discussed the forces a rocket would have to contend with as it passes through the atmosphere on the way to space. A chemistry major talked about fuels especially the new biofuels and their impact on the aviation industry. Civil engineers discussed the construction of new airfields, particularly runway length and material to use for support of the aircraft weight. Biology majors discussed the impact of altitude and its lower oxygen levels on the human body as well as other human factor issues such as G-induced loss of consciousness. Mechanical engineers talked about propulsion systems (Brayton cycle), their impact on aircraft performance, and the new materials being considered to reduce weight. Electrical engineers looked at aircraft systems, in particular the control systems. Systems and Operations Research Cadets discussed the acquisition process for new aircraft and equipment. Political Science Cadets looked at the impact of budget cuts on the USAF and is implications to future aircraft acquisitions and national policy. These are a good cross-section of the papers and, as can be seen, the topics were very thoughtful and satisfied the requirements of the assignment.

Assessment Survey

All 23 of the students participated in the survey. Since the author was only teaching at the USAF Academy for one year this was the only opportunity to use this assignment. Students were asked to answer the following questions on a 1 to 5 scale with 1 being “Strongly Disagree” and 5 being “Strongly Agree.”

1. Fundamentals of Aeronautics is important to me as a future U. S. Air Force officer.
2. The instructions on the Instructor Points AE 315 were extremely clear and left no doubt about the essay requirement.
3. The timing for the assignment was just right for this course.
4. It was difficult for me to decide on a topic that satisfied this essay requirement.
5. I enjoyed writing this essay.
6. I learned interesting things about my own academic major by writing this essay.

The results of the survey are as follows:

Table 1 Survey Results

Question	Result
1	4.3
2	4.5
3	4.5
4	2.0
5	3.8
6	3.1

The results were very encouraging. Cadets thought the assignment was valuable and clearly presented. They commented that in the USAF it was important to know something about airplanes. Also the time allotted was just about right. Cadets liked that the essay was introduced early in the semester and required completion later in the semester after a majority of the course had been taught. It gave them more course content from which to draw upon in their essays. Cadets were able to find a topic rather quickly so this did not present a problem. The last two questions had somewhat neutral results. Overall comments and suggestions where informative and helpful. One Cadet thought it was a great assignment and a fair way to allocate the Instructor Points. Another said it was a great assignment, easy to accomplish, applicable and interesting. One Cadet said they were amazed at how many of the aero concepts overlapped with their major. Several stated that this assignment allowed time for thought how the "fuzzy major" ties in with a more technical major. The criticism was the assignment was not specified enough with a grading rubric, enhanced point breakdown, and examples of what was expected. One Cadet wrote that they already knew everything they were going to write and did not have to accomplish research so they did not learn anything new. No literature search was required however a number of students used several references outside the course. In general the assignment was well received and satisfied the objective of challenging Cadets to think about how this service course intersects with their major. Requiring Cadets to take this time out of their busy schedules to consider why the course was necessary for their education was important. Given the results, a reflective essay to make the connections is recommended for future offerings of this course or any other service course.

Conclusions

This paper examined service courses, looking at how liberal arts supports engineering and how engineering supports liberal arts. Many more courses are taken by engineers outside their major than corresponding liberal arts students. A case is made for the need for technological literacy with courses provided by engineering departments. Service courses can also be offered by engineering departments to other engineering departments. Often students are not aware of the reason for these service courses and need to be reminded of their importance to the major. The example given in the paper involves liberal arts students required to take a technical course in aeronautics. The reflective essay was proposed as an excellent way to have the students find the intersection of their major with the service course.

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