Engineering Education in a Liberal Arts Environment at Baylor University

Ken Van Treuren, Steven Eisenbarth
Baylor University

Abstract

Engineering programs that exist in a liberal arts environment struggle to be understood. They constantly have to defend their program to university administrators, administrators who are not engineers or science oriented by education. This paper outlines the development of engineering as an intellectual discipline, putting it on equal terms with arts and sciences. Next, the paper traces the development of Baylor University's engineering program from 1979 to present. The motivations for this engineering program and the growth of the program over the past two decades are examined. Baylor University's Baptist heritage has also significantly impacted the present program. The present program is analyzed with the constraints imposed by accreditation and the institution itself. The conclusion reached is that there are few academic courses available for development of a liberal arts concentration. Baylor University is in the midst of defining itself in terms of a 10-year vision. This has resulted in an Academic Summit which is imposing additional liberal arts requirements. In the end, three questions are posed: 1) Are Specialized Liberal Arts Courses Required?; 2) Can Engineering & Liberal Arts be Integrated?; and 3) How Can the Liberal Arts Support Engineering? Lastly, this paper examines the integration of liberal arts into engineering education to develop a Christian worldview as stated in Baylor University's mission statement. The authors conclude that a common liberal arts core for Baylor University is not the answer for engineering programs and proposals are given to satisfy liberal arts requirements.

Introduction

V. James Mannoia Jr. points out in his book *Christian Liberal Arts: An Education That Goes Beyond* that defining the term liberal arts is not without difficulty[1]. The "basket approach" would describe the content of a liberal arts education as a collection of skills or competencies. This collection could include elements of oral and written expression, analytical and critical thinking, familiarity with great literary works, an understanding of ethical and moral imperatives, a grasp of cultural history, just to name the more obvious. Clearly the process of adding to the basket is subjective.

Others would use an "a priori" approach with focus on self-evident themes and principles following classical education designs championed by icons such as Cicero (education of the citizen) and Plato (learning for learning's sake). For the most part, this approach focuses on the cultural past in an attempt to understand and interpret the present. By implication, the most

effective means of coping with our modern world and the dilemmas of modern man are to utilize the categories and analytical techniques of the past. This proposition seems debatable at best.

Many from the science and engineering disciplines would take an exclusive approach, which would define liberal arts as what is of value when science, mathematics, and technology are removed from a curriculum. This narrow viewpoint appears to ignore a great body of knowledge that is key to understanding our present social and cultural dilemmas.

However one might struggle to construct a conceptual definition of liberal arts, this paper shall rely mostly on an "historical" approach, defining liberal arts as it has been practiced at Baylor over the last 155 years. This approach values Baylor's self-assertion that it has a long and strong liberal tradition and seeks to, as Mannoia would say, "link the meaning of liberal arts today to their roots in the past".

In its Mission Statement, Baylor proclaims that "the University seeks to familiarize students with the principal bodies of knowledge, cultural viewpoints, belief systems, and aesthetic perspectives that affect the world in which we live" and "Baylor encourages all of its students to cultivate their capacity to think critically, to assess information from a Christian perspective, to arrive at informed and reasoned conclusions, and to become lifelong learners." As a working definition for this paper, the liberal arts are those courses that significantly, although not exclusively, support these aspects of Baylor's Mission Statement.

The comments of Mark Roche, Dean of Arts and Letters at the University of Notre Dame, would support such a definition linked to the Baylor Mission Statement[2]. He proposed three values of a liberal arts education: first, the Plato approach of learning for learning's sake; second, cultivation of intellectual virtues that are requisite for success beyond the academy; and last, character formation and the development of a sense of vocation. All three of these values find parallel expression in Baylor's Mission Statement.

Engineering as an Intellectual Discipline

Engineering is an ancient discipline that can trace its roots to the beginnings of civilization. Engineers were instrumental in the building of the ancient Mesopotamian irrigation systems, the Egyptian pyramids, and civic structures such as aqueducts, temples and roads. Engineers were also attached to military units, being responsible for siege works, military weapons development and transportation infrastructures. With the rise of the scientific method engineers adapted the investigative and analytic techniques that accompanied the scientific revolution. This shift transformed engineering from an art based on trial and error into a discipline that specializes in the application of mathematics and science to solve engineering problems.

The modern engineer is dedicated to developing solutions to problems that directly impact the technical infrastructure of civilization and thereby not only the quality of life but life itself. Because the impact of engineering has been so great, the profession has developed high standards of ethics and professional excellence. It is with these standards in mind that the

education of engineers in mathematics and sciences and also in the arts and humanities must be carefully crafted.

Engineering At Baylor

Although Baylor has a long tradition of liberal arts education, it has only in the last decade expanded its vision in terms of applied science and technology with the establishment of the School of Engineering and Computer Science in 1995. The engineering program at Baylor began in 1979. The initial focus of engineering was to build a program that could be accredited by the Accrediting Board for Engineering and Technology (ABET). Accreditation was the goal principally because engineering is a regulated profession, with state licensing requirements for professional practice. An accredited program is a significant factor in the licensing process, which insures a steady source of well qualified, and technically competent engineering talent.

Baylor's initial curriculum development in engineering focused on the structure and content of engineering courses with little effort expended on developing a coherent liberal arts component for these programs. For the most part, liberal arts requirements were inherited from the Bachelor of Science (B.S.) degree. However, the B.S. hours were not specified. For the degree granted by the Department of Engineering, B.S. in Engineering Science (B.S.E.S.), a detailed list of approved humanities and social science courses was developed from which the students could choose to satisfy requirements. The list was not exclusive and included other courses not typically classified as either humanities or social science. The B.S.E.S. program required six more hours of humanities and social science above the Baylor B.S. baseline.

The minimum number of semester hours was also set at 129, five hours above the Baylor minimum for the B.S. degree. The 129-hour program assumed that students came with significant validation or transfer credit in modern foreign language and mathematics. For many remedial students, graduation required at least 143 semester hours.

In the 1983-1984 undergraduate catalog, the non-engineering/non-math/non-science component of the engineering degree was composed of two writing courses (ENG-1302, Thinking and Writing, and ENG 3300, Scientific and Technical Writing), two literature courses (ENG-2300, English Literature before Burns, and one of ENG 2302, English Literature since Burns, ENG 2304, American Literature: Masterpieces, or ENG 2306, Western World Literature: Masterpieces in Translation), two religion courses (REL-1315, The Religion of the Bible, and 1392, The Christian Faith and Business Ethics, or REL 1301, Old Testament History, and 1311, New Testament History), at least one course in foreign language, one course in political science (PSC-2302, American Constitutional Development) and four humanities and social science courses to be chosen from an approved list that ranged from the visual arts to aerospace studies. The approved list of humanities and social science courses was updated to include courses thought to strengthen a student's professional non-engineering skills. For this reason, a speech course, an engineering economics course, and a management course were highly recommended and the faculty advised students to take these courses.

In the mid 90's these course recommendations were slowly abandoned and students were allowed greater freedom in the choice of electives. Presently, the four humanities and social science elective courses have now been reduced to a course in engineering economics, and another in ethics. Six hours were converted to engineering hours, which provided an avenue for engineering internships and an increase in engineering elective hours.

Engineering and Curricular Constraints

Constraints are placed on the content of all engineering curriculum from a number of sources, however one source, the accreditation process, outweighs all others. This fosters similarities across educational institutions, both historically liberal arts oriented as well as those specifically founded to promote technical and science education. ABET prescribes minimum requirements in math, science, engineering, and the humanities and social sciences. The guidance for the humanities and social science component is much broader than the technical component and merely requires the non-technical components support the overall mission of the university.

Within the EC 2000, accreditation criteria the humanities and social science curricular elements are included under a "general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives" (Criterion 4 Professional Component). Criterion 3 (Program Outcomes and Assessment), also known as the "a thru k" outcomes, list desired characteristics of an engineering program. Outcomes "f thru j" specifically mandate engineering programs demonstrate that graduates have:

> (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 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.

A successful program evaluation under EC 2000 accreditation guidelines would use the non-technical humanities and social science degree components in combination with specific professional elements within the engineering program to support the (f) through (j) elements of the ABET Criterion 3. Specifically for Baylor University, the ethics elective supports element (f) and ENG-1302 and 3300 supports element (g), while the balance of the humanities and social science component (political science, religion, foreign language and literature) should support elements (h) through (j).

Current Program

For the purpose of this paper, the humanities and social science core present in Baylor's engineering curriculum will be more narrowly defined by removing the writing skills courses ENG 1302 and 3300. This adjustment is made simply because the content of these two courses is only peripherally related to the core content of typical humanities and social science courses.

This adjustment brings the total humanities and social science component in engineering to 8 courses or 24 semester hours.

In the 2000/01 Undergraduate Catalog, six of these 24 semester hours have been specified as an ethics elective chosen from REL-3390, Christian Ethics, REL 3392, The Christian Faith and Business Ethics, REL 4393, Environmental Ethics, REL 4395, Bioethics, or BUS 3350, Christian Ethics Applied to Business, plus an engineering economics course, ECO 3308, Engineering Economic Analysis. The ethics elective and the engineering economics course are important elements for supporting accreditation and must be required of engineering graduates. The literature, foreign language, religion and political science content was left unchanged, except for an adjustment to the literature sequence initiated by the English department. The humanities and social science core is now reduced to six courses or 18 semester hours of a minimum 136 semester hour degree program.

Support for a Liberal Arts Component

When broken down into subject categories, the present program contains only an 18-hour component for a true liberal arts core. Because of the historic Christian heritage of Baylor University, a commitment to maintain the six-hour religion component is without question, however, the ethics course coupled with a single survey of the Bible course could possibly meet this historic objective, fulfill Baylor's Mission Statement, and give engineering students three more hours that are not specified.

Removing the six hours used for the religion requirements from the liberal arts core leaves only four courses to define and build a coherent humanities and social science or liberal arts component for the engineering program. At present these courses are specified as two literature courses, minimally one foreign language course, and a political science course. It would appear that this present sequence is inadequate in terms of a coherent liberal arts experience for the undergraduate engineering student.

The 2012 Vision Statement

The university is presently engaged in the process of defining a 10-year vision that is described in a document entitled *Baylor 2012: The Vision Begins*[3]. Ten "core convictions" are key to this vision. Core convictions such as "Facilitate the discovery of new knowledge to advance society" are clearly understood by engineers as their charge upon graduation. The EC 2000 outcomes are forcing engineers and engineering programs to consider other aspects of engineering education that overlap with areas that could be interpreted as liberal arts. Baylor uses terms such as "Encourage the understanding and care of the natural world," "Strive to illuminate and enrich the human experience," and "Equip individuals to understand life as a calling and thus serve society and the world." While noble goals, these statements are not written in language clearly understood by engineers. The process of assessing these convictions in the context of the engineering curriculum is even more difficult to visualize. This is an area where liberal arts could enhance engineering education by helping to develop courses to address these goals. With the limited number of available courses, the desired result seems doubtful. Liberal arts education

must be integrated within engineering courses if there is any possibility to support both EC 2000 and the Baylor Vision Statement. The integration of this knowledge must be done without compromising the content and quality of the technical courses.

2001 Academic Summit

Baylor's Provost has organized a series of annual academic summits. The participants are deans and chairpersons from all academic units of the university. The 2001 summit focused on the content and quality of the undergraduate experience. Several recommendations were made including the development of a course sequence in "Great Texts" or "Master Works", a requirement for foreign language proficiency, addition of significant writing and speaking components throughout the curriculum, and introduction of inquiry based science courses. These recommendations are part of a "common core" reform that would impact all Baylor students.

The Summit's recommendations were generated from deeper pedagogical concerns of how to develop a student's skills in the art of intellectual inquiry as well as concerns that students understand fundamental human issues, the role of culture in human experience, and the role of the arts in human expression. Since the Summit's recommendation represents a general consensus of Baylor's academic governance, any proposal that would reform the liberal arts core of the engineering degree should respond to the Summit's concerns. To encompass all the "requirements" of the Summit would, of necessity, mean more required courses for engineering students and raise the number of hours for graduation. Engineering students typically take between 4.5 and 5 years to graduate.

Issue: Are Specialized Liberal Arts Courses Required?

Another approach would be to request that specifically designed liberal arts courses be developed for engineering students. From an institutional prospective this solution may not be viable because of the relatively small number of engineering students involved. Service courses taught by one department for non-majors are typically taught in large sections to reduce the overhead and repeated every semester to reduce faculty preparation loads. For these reasons, any special course development will require that the course attract non-engineering students to raise class sizes and frequency. One such example is ENG 3300, Technical and Professional Writing, which now attracts more non-engineering students than engineering students. A counter example is Engineering Economics (ECO 3308) which is taught only once per academic year specifically for engineering students.

Issue: Can Engineering & Liberal Arts be Integrated?

In the last 30 years several attempts have been made to "integrate" elements of the undergraduate curriculum. The Baylor Interdisciplinary Core (BIC) is one such attempt at this institution. Most would assume that it is difficult or maybe impossible to integrate elements of liberal arts and engineering. First, many of the engineering faculty and students treat the liberal arts as if they had little relevance to their technical interests. There is a deep divide that continues for a number of reasons. The engineering faculty itself has been educated in a liberal arts poor

curriculum. For the most part, they are not fully informed or aware of the richness of the liberal arts tradition or the intersection between the disciplines. This situation is obviously symmetric: most liberal arts faculty being intellectually uninformed vis-à-vis science, mathematics and technology. Therefore, any attempt at creating a set of special courses that would integrate liberal arts elements with the engineering experience would first require special faculty development. Particularly relevant are faculty retreats similar in structure and purpose to the 2001 Lilly Foundation sponsored retreat on vocation conducted by Baylor University in May 2001. Representatives from most academic disciplines attended this event.

Issue: How Can the Liberal Arts Support Engineering?

Up until now the discussion has been how engineering students interact with the liberal arts structure in the university and the benefits (or lack thereof) derived from this association. The question must also be asked as to how Baylor University's liberal arts can support engineering education? Clearly, as stated above, classes addressing or at least acknowledging the presence of engineering students are needed. This would benefit engineering students tremendously. For example, the Department of History offers 61 different history courses, not one of which covers the history of science, technology or engineering. Another example, 37 Spanish courses are taught, not one of which deals with scientific or technical communications in Spanish. For the most part, the liberal arts faculties have not addressed the need or the opportunities for attracting science and engineering students to their disciplines.

The current B.S. in Engineering (B.S.E.) degree requirements are thoroughly compartmentalized into three broad categories: mathematics and science, liberal arts, and engineering and technology. There is not one course of the 136 hours required that bridges the gaps between the liberal arts and engineering. Certainly, for mathematics and science, engineering is the arena of application. Are there not some other areas of overlap between technology and the liberal arts?

Integration to Develop a Christian Worldview

Clearly, Baylor's liberal arts tradition is anchored to its Christian heritage. Mark Roche's comments presented in the introduction to this paper are very important to the Baylor University mission. He stated that the third value of a liberal arts education is character formation and the development of a sense of vocation. One bridge that could be built between the liberal arts and engineering involves both character building and the development of a sense of vocation within the framework of the Christian faith. This bridge could provide a unique element that could distinguish Baylor's engineering graduates from those of other institutions.

The foundation of this bridge must involve the development of a central intellectual and cultural perspective that can support a worldview from which moral and ethical imperatives can be developed. From the Christian perspective, this foundation is rooted in the revelation of God and the work of Jesus Christ. By necessity, the study of Old and New Testament literature and the fundamental truths of the Christian faith are key. But from this foundation, additional structures that focus on the nature of man and the nature of culture must be built. Key to filling in the superstructure is the presence of liberal arts course that connect the Christian faith to a sense of

Christian culture and Christian social values. The final linkage would connect these values to the vocation of engineering so as to produce a graduate that is aware of the social consequences of the engineering arts and able to contribute in significant way to the social fabric.

A Proposal

This proposal begins with the premise that Baylor should not attempt to develop a common liberal arts core for all students. Rather than uniformity, Baylor should pursue diversity and adapt its liberal arts heritage to meet the needs of its growing diversity of educational programs. Specifically, Baylor should tailor a liberal arts component specifically addressing the needs of the student that seeks an engineering degree. This component should involve core liberal arts courses that have distinctive Christian points of view and which would culminate in a course that integrates the liberal and technical arts.

The engineering program has very little flexibility in term of the mathematics, science and engineering components, primarily dictated by accreditation standards. Therefore, as a first goal, a coherent liberal arts core should allow some student choice of subject matter while maintaining coherence, simply to accommodate individual interests of students. A moderate proposal might involve the generation of course groupings around a common thread of ideas or intellectual disciplines.

As a second goal, and in support of the 2012 Vision Statement, some weight should be given to the great intellectual and cultural traditions of western civilization not necessarily to the exclusion of Asian or African civilization but as a first principle starting point. Concomitantly, some deference should be given to the presence of "great books" or "great works" and the study of original literary sources.

As a third and fourth goal, the liberal arts core should provide opportunities for students to engage in written and oral communications and there should be depth with the content spread between introductory, intermediate and advanced courses.

A final goal would be to develop a new course that strives to integrate the liberal and technical arts. The content of this course should focus on a Christian worldview with ethical and moral applications for the technical arts. Initially, this course should be developed with a broad spectrum of faculty input including engineering, religion, philosophy and other appropriate science and liberal arts faculty. Joan Burtner at Mercer University is developing such a course titled "Engineering, Technology, and Society" open to the entire university[4]. While this course addresses the topics in the title, it does not even try to do so from a Christian worldview. The Christian worldview would make such a course a valuable opportunity for dialogue on how the world of technology and the liberal arts overlap within this Christian context.

Given these goals, the question is how does one proceed to create or specify a set of courses that would comprise a liberal arts core that addresses the specific need of students pursuing a technical education? One could start with courses that are presently offered using the catalog course descriptions as a guide. Examples, which on the surface might meet the goals, stated

above, is a collection grouped around a common intellectual thread. An example of common thread grouping might be a HIS-1303 (Modern World Civilizations since 1750), ENG-2301 (English Literature), PHI-2310 (Law, Science, and Society) and a fourth course at the 2000 level or above in history, literature or philosophy. A second example might be a foreign language course at the 2000 level or above, ANT-3301 (Science, Society, and Culture), PSC-3324 (World Political Systems) plus a 2000 level or above in political science, sociology, or foreign language.

Conclusion

The engineering faculty, for the most part, would agree that the values of a liberal arts education are also important values for an engineering education at Baylor University. Engineering programs operating in a liberal arts environment are not unique to Baylor University. What is somewhat unique to Baylor is the desire to operate within the context of a Baptist heritage and to train engineers with a Christian worldview. With this foundational requirement, engineering education at Baylor University becomes more complicated than the average engineering school operating within the liberal arts environment. Therefore, in principle, the purpose of a liberal arts education is completely compatible with education of engineers, however, the content of the curriculum for a liberal arts major and an engineering major seem worlds apart. It is this gap that must be bridged if engineering students are to benefit from the best of what liberal arts have to offer.

References

1. Mannoia, V. James, Jr., 2000, *Christian Liberal Arts: An Education that Goes Beyond*, Rowman & Littlefield Publishers Inc., Maryland, pp 9-11.

2. Roche, Mark, 2001, "The Three-Fold Value of a Liberal Arts Education", Presented at Baylor University conference on "Vocation and a Liberal Education," May 2001.

3. *Baylor 2012: The Ten-year Vision*, Draft: Long Version

4. Burtner, Joan A., 2001, "Engineering, Technology, and Society: Increasing the Dialogue Between Liberal Arts Majors and Engineering Students," Presented at the ASEE Summer Annual Meeting, Jun 2001.

KEN VAN TREUREN
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 and his M. S. in Engineering from Princeton University. He completed his DPhil in Engineering Sciences at the University of Oxford, UK. At Baylor he teaches courses in laboratory techniques, fluid mechanics, energy systems, propulsion, and freshman engineering.

STEVEN EISENBARTH
Steven Eisenbarth is Associate Dean of the School of Engineering and Computer Science at Baylor University. He received his B.S. in Mathematics and Physics from Albertson College of Idaho and a Masters and Ph.D. in Physics from Baylor University. He teaches courses in electrical and computer engineering including embedded computer systems design, computer organization, electrical materials, and microprocessor systems.