Reclaiming General Education: History for Engineers

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Abstract

US institutions generally take a broad view of higher education, requiring all students, regardless of major, to take courses in a variety of subject areas. These general education courses are often considered by engineering students to be unrelated to their chosen profession and are therefore seen merely as hoops to be jumped through on the way to graduation. However, these courses make up a significant percentage of students' overall credit requirements, and represent a mostly untapped opportunity to meaningfully incorporate the global and societal context required by ABET into an engineering degree program. By partnering with the humanities and social science faculty who teach these distribution requirements, engineering programs have an opportunity to reclaim this portion of the university experience, making it a meaningful component of students' professional formation as engineers.

This paper will discuss a new, two course sequence that students can use to meet the history requirements at the University of Alabama at Birmingham. The courses were developed and are being co-taught by the authors, a history professor and an engineering professor. The course sequence, entitled "World History and Technology" departs significantly from traditional world history courses by using a Big History textbook as a basis for the course content, along with a variety of activities, group projects and guest speakers. The paper discusses the motivation for creating the course sequence, some challenges in getting it approved as a distribution requirement by the university, the experience of teaching it for the first time during the 2017-2018 academic year, and plans for the future.

Introduction

In 1997, ABET rolled out the Engineering Criteria 2000 (EC2000), which introduced for the first time an understanding of social context as a requirement for engineering education. This is an acknowledgement that engineering practice does not occur in a vacuum, but must be responsive to the various economic, political, and cultural forces around it. In the years since EC2000, many engineering programs have struggled to meet this criteria in a meaningful way [1]. The reasons are primarily two-fold. First, the addition of so-called "soft skills" into the curriculum in no way reduces the amount of technical content that is also necessary to cover, and engineering curricula are notoriously content-heavy already. As Passow notes in a study of the relative importance of various ABET competencies to recent graduates, "Engineering faculty may groan inwardly at the notion of adding anything to their jam-packed curriculum [2]." Secondly, engineering faculty may have a difficult time effectively incorporating non-technical concepts into their courses [3]. The expertise related to the interplay between history, politics, culture, religion, economics and so forth is, by definition, located in the humanities and social sciences. However, there is a strong silo effect at most institutions of higher education, so that the individuals responsible for transmitting and developing engineering knowledge in students are institutionally isolated from the people responsible for developing and circulating knowledge about history, society and culture [1]. However, without input from engineering and science faculty, professors in the humanities and social sciences are unlikely to consistently incorporate

issues of technology into their general courses, or to do so in a way that is relevant and meaningful to the students.

One approach that addresses both issues is to reconsider the courses that engineering students take outside of engineering. Institutions in the United States generally take a broad view of higher education, requiring all students, regardless of major, to take courses in a variety of subject areas. These general education courses are often brushed off by engineering students because who view the courses as entirely unrelated to their chosen profession. However, these courses make up a significant portion of students' overall degree programs. At the authors' university, 36 of the 128 required credits (28%) for a BS in engineering fall outside of engineering, math and science. These courses represent a mostly untapped opportunity to meaningfully incorporate global and societal context into an engineering degree program. By partnering with the humanities and social science faculty who teach these distribution requirements, engineering programs have an opportunity to reclaim this portion of the university experience, making it a meaningful component of students' professional formation as engineers. The advantages of utilizing liberal education courses to meet the extended educational needs of engineering students is clearly articulated in [4], where the authors describe bringing archival objects from the university library to bring science and technology to life for first year engineering students in a humanities course.

While such partnerships may take many forms, we propose that history is a particularly good place to start. As historians Geselowiz and Vardalas note, "The story of technology is inseparable from the greater narrative of humanity [1]." World history also necessarily exposes students to technical solutions from diverse geographic and cultural settings. There is a strong feeling among engineering faculty that understanding history makes one a better engineer [5]. Studying the history of technology may be particularly useful in helping students understand why engineering solutions must be specific to their time and place [6]. In fact, the disciplinary processes of history and engineering share a surprising number of similarities, as outlined by Dias [6], who concludes that "engineering students and practitioners probably need good doses of history, because an appreciation of a parallel discipline will give greater insights into the way one's own discipline should operate." Although there have been notable efforts in the past to marry these two disciplines at the undergraduate level [7-9], those remain the exception rather than the rule, and the usual method of teaching history at most universities does not help students to make these connections. Described below is a new approach to history for engineering students being undertaken at the University of Alabama at Birmingham. A new two-course sequence of world history courses was developed and offered which meets the unversity's undergraduate history requirements.

Course Development

The impetus for the new history courses began when Dr. Amber Genau, a faculty member in the department of Materials Science and Engineering, was serving as academic advisor for some of the students in her department. She learned that all UAB undergraduates are required to take at least one history course, as well as one "sequence" of courses, a requirement which can be met either with two history courses or two literature courses. The only history courses at UAB from which to choose were US History I & II, World History I & II, and Western Civilizations I & II.

Many students were bored and frustrated with the limited course offerings, which repeated topics they had covered in high school. A number of students opted to meet the requirement by taking a history course during the summer from a local community college at a lower tuition rate.

The address this issue, Dr. Genau approached Dr. André Millard, a historian of technology within UAB's History department. Dr. Millard was an editor on the Thomas Edison Papers Project and has published on the interaction of technology and culture in a number of contexts. His publications on Edison's West Orange laboratory, the rise and fall of the recording industry, and the technological underpinnings of Beatlemania have been used as readings in the second part of the course [10, 11, 12]. Dr. Millard joined the project with enthusiasm. In order to get a feel for engineering students and how engineering courses are typically conducted, he sat in on a number of engineering classes. Noting that group projects and oral presentations are common requirements for engineering students, those activities were incorporated into the history classes. Note, however, that because the core distribution classes cannot be specific to any major or discipline, the courses are not limited to engineering students. The courses also have no prerequisites.

Before beginning this project, Dr. Genau began teaching a history-rich course called the Evolution of Engineering Materials as a technical elective within her department. The course was offered as a study abroad class in Germany (see [13], [14] for details) and very well received by students. Some of the content from that course informed the development of the new history courses.

The authors also surveyed the web to find out what equivalent courses, if any, were being offered at regional peer institutions. Auburn University has a two-course *Technology and Civilization* (HIST 1210/1220) sequence that meets the same state-mandated core requirements, with multiple sections of each offered every semester, indicating a high degree of student interest. Fruitful discussions with the primary instructor, Dr. Angela Lakwete, (who also provided copies of her syllabi) informed the development of the UAB classes. The University of Alabama offers a two-course *History of Science* (HY 115/116) sequence, which covers both science and technology. Georgia Tech offers *Engineering in History* (HTS 108) which uses historical case studies to examine the relationship between engineering and society, is taught jointly by history and engineering faculty, and meets an equivalent social sciences requirement.

Together, Drs. Genau and Millard crafted a proposal for a new, two-course sequence that could be used to meet both the university's core history requirement and the sequence requirement. The proposed courses encountered significant opposition both from other members of the history department and the larger College of Arts and Sciences. First, some faculty were opposed to any change in the status quo because they were concerned about loss of credit hour production, partly due to the misconception that engineering was trying to get permission for their students to stop taking history classes. Other faculty argued that a "pure" version of their discipline was necessary at the introductory level, and that anything else was somehow pandering to the students. Meetings between the authors, their department chairs, and their respective deans were held to discuss these and other issues. In response to the first issue, we pointed out that these new courses were actually likely to result in more students enrolling in history classes, as a more appealing option would encourage additional students to take a second history course to meet

their sequence requirement and fewer students would use transient enrollment at another institution to meet the requirement. We also pointed out that courses equivalent to those we were proposing were already being offered at other institutions in the region and we were rather behind the times in this respect. In response to the philosophical arguments about content, we reminded people that all of world history is never going to be covered in two three-credit, freshman-level courses. Every course must make choices about what content to include. These courses would still be covering world history, as defined by a historian, but using the lens of technology to consider the progression of that history.

Eventually, the courses were approved by the history department, the dean of the College of Arts and Sciences, the Faculty Senate Curriculum Committee, the full Faculty Senate, and the Provost. The final approval came in spring 2017, three years after the authors first began discussions, and the classes were taught for the first time during the 2017-2018 academic year.

Course Overview

The catalog descriptions for the two new history courses are given below.

HY 106. World History and Technology I. 3 Hours.
Survey of the role of technology in history from prehistoric times to the beginning of the Scientific Revolution. The first of a two-course sequence, it begins with the formation of the universe and ends with the era of European global expansion. The course uses technology as a lens through which to study humans' increasing control of the environment and interactions with the world around them. Co-taught with an engineering faculty member.

HY 107. World History and Technology II. 3 Hours.
Survey of the role of technology in history from the Enlightenment to the present day. It is the second of a two-course sequence. The course moves through the British Industrial Revolution in the 17th century and ends in the 21st century with examination of current issues and trends. Both the positive and negative impacts of technology development, including imperialism and Third World development, will be addressed. Co-taught with an engineering faculty member.

The first course departs rather significantly from traditional world history courses by using a Big History textbook as a basis for the course [15]. Big History utilizes the findings of a variety of scientific technologies developed in the mid-20th century to tell a universal origin story of the human species, beginning with the Big Bang and the formation of the university itself. The early sections of the book (and the course) cover simultaneously (1) what is known about the formation of the universe, stars, our solar system, and the origin and evolution of life, and (2) the development of scientific thought and the technologies that allow us to piece together the evidence for our past, along with as the individual investigators and inventors who carried out the work. Once humans appear on the scene, an extended period is spent on the Paleolithic and Neolithic periods, before moving on to the rise of various early civilizations and increasing regional and global networks, leading to an ever increasing rate of development of technology and society. We discussed with students the backlash that often occurs as individuals struggle with a world that is increasingly complex and difficult to understand, connecting historical examples to the current debate over global warming, for example, and emphasizing the importance of communication to non-technical audiences.

The second course begins with the Scientific and Industrial Revolutions, then covers the remainder of the 20th and 21st centuries through a series of topical areas such as aviation, warfare, and medicine. Like the textbook, the course ends with "the history of the future," using historical tools and trends to predict what might occur in the near, middle and long-term future. This provides many opportunities to incorporate discussions of population growth, resource utilization, and environmental protection. Throughout, we emphasize the distinction between science and engineering, and between evidence and conjecture. We also stress the similarities between historic and scientific methods of knowing, from using a variety of tools to obtain evidence, which is often fragmentary, to drawing conclusions and publishing for evaluation by peers, to re-evaluation when new evidence appears, which, in the case of historical evidence, may be new artifacts that are uncovered or new scientific analysis methods that are brought to bear on existing artifacts.

Because one of the instructors is a materials engineer, a second book, *The Substance of Civilization: Materials and Human History from the Stone Age to the Age of Silicon* by Stephen Sass (Arcade Publishing, 2011), was also assigned reading. Both books were used both semesters. Additional reading assignments were posted on the university learning management system (Canvas), including chapters from several of Dr. Millard's books, articles identified with help from the UAB engineering librarian, and readings suggested by guest lecturers.

Building on the model of UAB's University Honors Program, the authors invited many of our colleagues to join us in creating an interdisciplinary class experience. We have drawn on several departments in the School of Engineering, not only to bring in other fields of knowledge but also different approaches to pedagogy. We have exploited some interesting new initiatives within the School of Engineering, such as the "Smart Cities" project developed by the Department of Civil, Construction and Environmental Engineering. We also encourage guest speakers to tell the students a little about their education and career choices, as we feel this provides valuable models for our students, most of whom are in their first or second year of studies and have limited interaction with engineering faculty.

In planning this class, the Dean of the School of Engineering lamented the lack of hands-on experiences in freshmen classes and the general decline of hand-eye coordination in engineering students. We have endeavored to correct this with a schedule of class trips such as a visit to a local blast furnace which has been converted to an industrial heritage site and several show-and-tell projects in class involving working models of steam engines and the Wright Flyer. Our goal from the beginning was to make this a different kind of history class with more interaction between faculty and students, and between students and machinery.

Course assessment included reading quizzes for each chapter administered via Canvas, midterm and final exams, classroom attendance and participation, and a group project. During the first semester, each group was asked to select a technology developed pre-500 CE and argue its importance to the "advancement of civilization" during a 15 minute oral presentation during the final week of the semester. In order to help the students make a successful presentation, the following scaffolding was incorporated throughout the semester: After assigning groups, each group was required to submit a short written proposal describing their desired topic. Once the topic was approved or revised by the instructors, the groups submitted a written outline of their

main points, coving technical issues, historical context, and societal impact. The outlines were subject to peer review by members of other groups using the peer review functionality built in to Canvas. Groups were able to revise their outlines based on peer feedback before assessment by the instructors. The week before the final presentations, one member of each group stood up in front of the class to give a brief introduction to their topic. This provided the instructors an opportunity to give guidance about appropriate speaking techniques. Students used the peer evaluation tool at CATME.org to provide formative and summative feedback to their group members and the instructors. During spring semester, the students were broken into groups to debate the pros and cons of various technological developments selected by the class (artificial intelligence, genetic engineering, etc). Each group was required to submit a written outline of their planned arguments and a short video introducing their topic before the in-class debates near the end of the semester. This activity is meant to emphasize that there are always both positive and negative consequences of technology, an important theme particularly of the second course.

Throughout the course, the instructors tried to use historical content to develop students preparing to enter technical professions. For example, during one class period, students worked in small groups to investigate an engineering disaster and write a short essay addressing what went wrong, what ethical issues surrounded the disaster, and what the effects of the disaster were in terms of changes to government oversight, societal opinions, etc. This activity emphasized that engineering decisions do not occur in a vacuum, while also allowing students to practice team work and clear written communication. This activity followed a lecture about the rise of engineering as a profession after the Industrial Revolution, as the increasing complexity of technology required a shift from the traditional art or craft basis (i.e. blacksmithing) to a scientific basis (metallurgical engineering) that required a particular kind of advanced education and certification. The role of engineering professional societies in crafting ethical codes, and the tension between engineers as independent skilled practitioners (like doctors or lawyers) and employees invested in the economic success of their corporation, were incorporated throughout these discussions. The aim is to help students understand the complex and conflicting roles that they will be inhabiting as they develop a professional engineering identity.

Student Outcomes

The initial offering of these courses met with relatively good success. Enrollment was full in both classes, capped by the size of the classroom (45). About half of the students were engineering were engineering or pre-engineering majors. Another quarter were physical sciences, computer science or some form of pre-med or pre-nursing, with the remainder coming from various departments across campus or being undeclared. About 65% of students from HY 106 in the fall enrolled in HY 107 in the spring.

The majority of students in both classes were freshmen. It is hoped that bringing additional engineering connections into the first year experience, including contact with multiple engineering faculty members, will strengthen these students' identification with engineering and improve retention. Although these classes are not exclusively for engineering students, the authors designed the classes to give the engineering students a strong start, establishing patterns of thinking that will accelerate their understanding of the complex issues they will face later in their education, and providing meaningful case studies that will enhance the engineering classes

they take. We also intend these classes to be a vehicle for students to begin to wrestle with issues of professional responsibility, ethical dilemmas and the complexities of the modern workplace. The classes are designed particularly to support ABET outcome (h): the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context, but we believe they are also effective in addressing a variety of other outcomes, including (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; (f) an understanding of professional and ethical responsibility; (g) an ability to communicate effectively; and (i) a recognition of the need for, and an ability to engage in life-long learning. Several assignments were created specifically to address the life-long learning objective, including one which requires students to find and submit a link to a current news article related to some aspect of history and technology, along with a description of the article and its connection to the class. One week during the second semester is devoted to the rise of engineering as a profession, the formation of engineering professional societies, and the role of standards and regulation in design.

As an additional benefit, an appreciation of history has been identified an important component of global competency. Bill Hunter, who gathered input from a variety of international sources to create one of the largest and most cited attempts to define global competency, states that "in order to become globally competent, one must establish a firm understanding of the concept of globalization and of world history. It is here that the recognition of the interconnectedness of society, politics, history, economics, the environment, and related topics becomes important [16]." Most discussions of global competency, including those specific to engineers, include knowledge of history as a means of better understand present status (see for example [17] and [18]). Global competency is a topic usually addressed through study abroad programs, but not all students have the interest or ability to go abroad. Numbers of students studying abroad are particularly low among engineering majors [19]. Incorporating aspects of global competency into on-campus courses in one alternative. Making required history courses more meaningful and relevant may therefore have the additional benefit of improving the global competency of engineering majors.

Future Directions

As this was the first year of these courses, a number of lessons were learned and revisions planned for the future. We would like to include more primary source material and utilize existing online resources, such as the Engineering and Technology History Wiki (formerly IEEE Global History Network). Our goal is to develop a strong base curriculum that heavily utilizes our LMS for reading quizzes and submission of assignments so that the course can be effectively packaged and expanded for use by other instructors, thereby allowing more than one section per semester.

One of the negotiations that was required to bring these courses into existence was the concession that all of the credit hour production go to the history department, even though half of the teaching is done by an engineering faculty member. This is an issue we are attempting to renegotiate. Ideally, we would like for a separate catalog section of EGR 106/107 to be offered,

thereby addressing the credit hour production issue while also reserving a portion of the seats for engineering and pre-engineering majors. A very similar arrangement between the School of Engineering and the math department has existed for several years, so we are hopeful that an agreement can be reached.

Longer term, we envision these courses as providing a template for other cross-campus collaborations. Faculty from the schools of business and nursing have expressed interest in developing history sections that would engaging and relevant to their schools. For students in engineering, we hope that core classes in additional areas can be added to address their particular educational needs. Most pressingly, all students are required to take an English writing course, but only students in the Science and Technology Honors Program are able to meet that requirement by taking a technical writing course. Courses like these will require new partnerships between faculty in professional schools and those in the arts and humanities. This requires a fundamental paradigm shift, where the goal of required intro-level history courses, for example, is not to create more history majors, but to equip future engineers, teachers, lawyers, doctors, nurses and business people with the tools of history in order to think more critically about the world and their place in it. With some creativity and innovation, we believe that required history classes can become a vital and engaging component of engineering education, rather than just another hoop to be jumped through on the path to graduation.

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